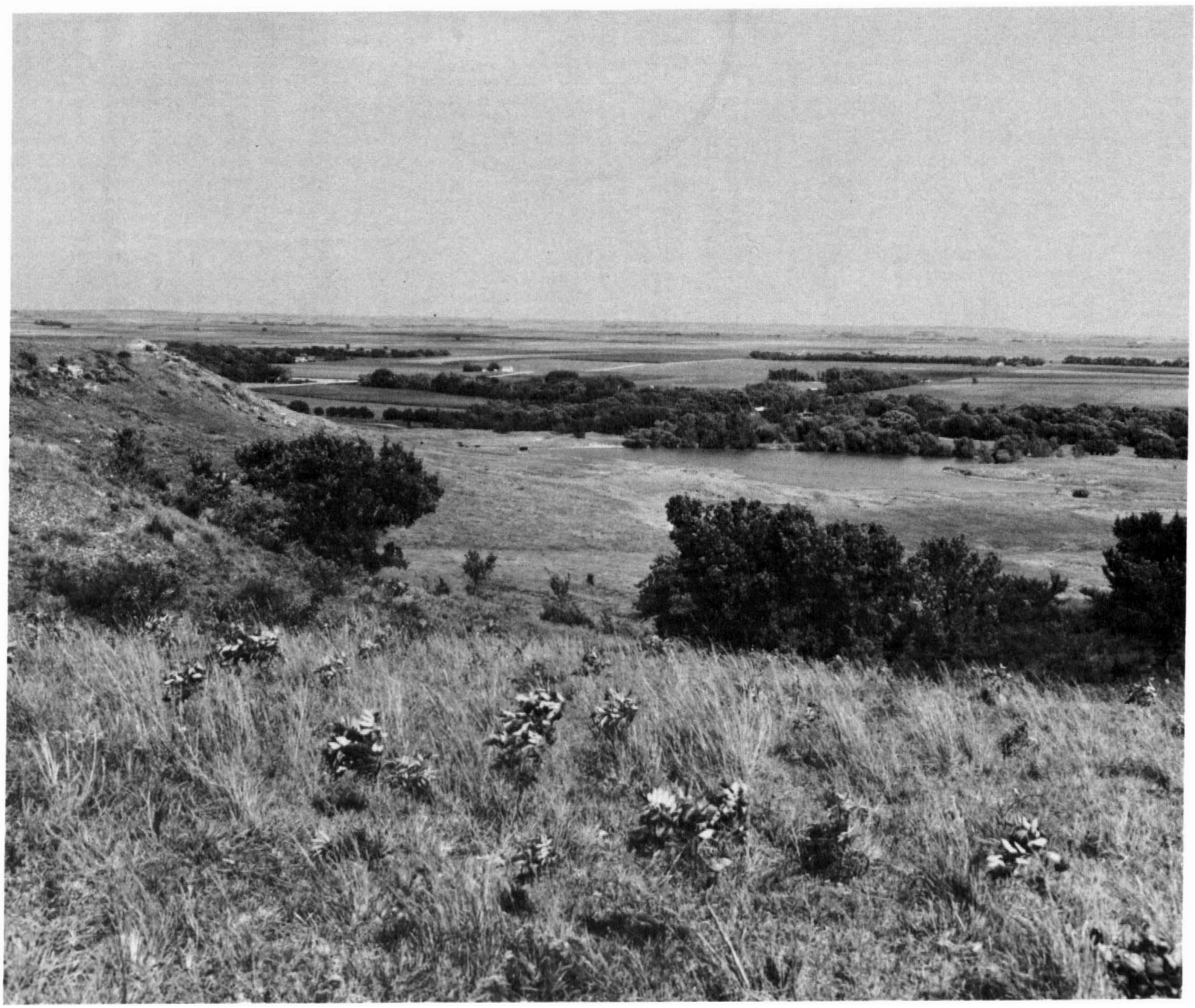
SOIL SURVEY OF

Smith County, Kansas



United States Department of Agriculture
Soil Conservation Service
In cooperation with
Kansas Agricultural Experiment Station

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey. In line with Department of Agriculture policies, benefits of this program are available to all who need the information, regardless of race, color, national origin, sex, religion, marital status, or age.

Major fieldwork for this soil survey was completed in the period 1966-73. Soil names and descriptions were approved in 1973. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1972. This survey was made cooperatively by the Soil Conservation Service and the Kansas Agricultural Experiment Station. It is part of the technical assistance furnished to the Smith County Conservation District.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms, ranches, woodlands, and wildlife areas; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of Smith County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the windbreak suitability group and range site in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the mapping units, range sites, and windbreak groups.

Foresters and others can refer to the section "Windbreaks" where the soils of the county are grouped according to their suitability for trees.

Wildlife managers and others can find information about soils and wildlife in the section "Wildlife."

Ranchers and others can find, under "Range," groupings of the soils according to their suitability for range, and also the names of many of the plants that grow on each range site.

Community planners and others can read about soil properties that affect the choice of sites for nonindustrial buildings and for recreation areas in the sections "Engineering" and "Recreation."

Engineers and builders can find, under "Engineering," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

Scientists and others can read about the soils in the section "Formation and Classification of the Soils."

Newcomers in the area may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given in the section "General Facts About the County."

Cover: Range on Heizer soils.

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Issued August, 1978

Summary of tables

SOIL SURVEY OF SMITH COUNTY, KANSAS

By Vernon L. Hamilton, Soil Conservation Service

United States Department of Agriculture, Soil Conservation Service, in cooperation with the Kansas Agricultural Experiment Station

SMITH COUNTY is in the north-central part of Kansas and has an area of about 571,520 acres, or 893 square miles (fig. 1).

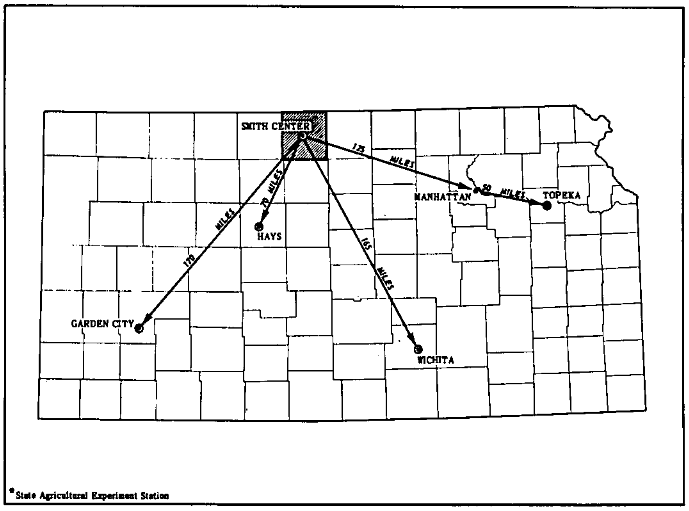

Figure 1.—**The location of Smith County in Kansas.**

Smith Center is the county seat and is near the center of the county. Other small towns in the county are Athol, Cedar, Gaylord, Harlan, Kensington, and Lebanon.

Agriculture and related services are the main occupations in Smith County. Cash grain, wheat, and grain sorghum, livestock, cattle, and hogs are the main sources of income. About two-fifths of the county is range and three-fifths is cultivated. About 6,000 acres along the North Fork of the Solomon River is under irrigation from the Kirwin Ditch. Corn, sorghums, and alfalfa are the main crops under irrigation. Alfalfa, silage crops, and forage sorghums are also grown for livestock feed under normal conditions.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Smith County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and nature of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Harney and Holdrege, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Harney silt loam, 1 to 3 percent slopes, is one of several phases within the Harney series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of

some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series or of different phases within one series. One such kind of mapping unit—soil complexes—is shown on the soil map of Smith County.

A soil complex consists of areas of two or more soils so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. McCook-Munjor complex is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely eroded that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names, such as "Alluvial land, loamy," which is a land type in Smith County.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, managers of woodland and range, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others, then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in the survey area. A soil association is a landscape that has a distinctive pattern of soils in defined proportions. It typically consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in an association can occur in other associations, but in different patterns.

A map showing soil associations is useful to people who want to have a general idea of the soils in a survey area, who want to compare different parts of that area, or who want to locate large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide for broad planning on a watershed, a wooded tract, or a wildlife area, or for broad planning of recreation facilities, community development, and such engineering works as transportation corridors. It is not a suitable map for detailed planning for management of a farm or field or for selecting the exact location of a road or building or other structure, because the soils within an association ordinarily vary in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The soil associations in this survey area are described on the pages that follow.

1. Uly-Holdrege-Campus association

Deep and moderately deep, gently sloping to steep, well drained, silty and loamy soils that formed in loess and caliche sediment on uplands

This association consists of loess-covered uplands dissected by intermittent drainageways that have side slopes underlain by limy outwash sediments of soft caliche. The soils are mostly gently sloping to sloping, but they are steep in places along the entrenched upland drainageways.

This association makes up about 4 percent of the county and is mostly in the northwestern part. It is about 40 percent Uly soils, 30 percent Holdrege soils, 15 percent Campus soils, and 15 percent minor soils (fig. 2).

Uly soils are strongly sloping to steep. They are on slightly convex side slopes along upland drainageways. The surface layer is typically grayish brown silt loam about 8 inches thick. The subsoil is friable, light brownish gray heavy silt loam. Very pale brown, calcareous silt loam is at a depth of about 24 inches.

Holdrege soils are gently sloping to strongly sloping. They are on convex upland divides. The surface layer is typically grayish brown silt loam about 10 inches thick. The subsoil is friable, grayish brown and pale brown silty clay loam. It is underlain by very pale brown, calcareous silt loam at a depth of about 28 inches.

Campus soils are sloping to strongly sloping. They are in a complex with the Canlon soils that are shallow over hard caliche on steep side slopes along entrenched drainageways in uplands. The surface layer is typically grayish brown loam about 8 inches thick. The subsoil is grayish brown light loam about 10 inches thick. The underlying material is light gray, calcareous light loam. Caliche is at a depth of 32 inches.

Of minor extent in this association are Canlon, Harney, Penden, and Roxbury soils. Canlon soils are shallow over caliche and are on steeper areas associated with Campus soils. Harney soils are gently sloping and are on uplands at the summits of the landscape. They have a subsoil of firm, heavy silty clay loam. Penden soils are sloping and are on uplands generally slightly above the Campus soils. They are loamy and have a calcareous layer. Roxbury soils are nearly level and are on flood plains that have entrenched drainage channels. They are deep, calcareous silt loams.

The available water capacity is high in Uly and Holdrege soils and moderate in Campus soils. Fertility and the content of organic matter are medium to high where the soils have not been eroded.

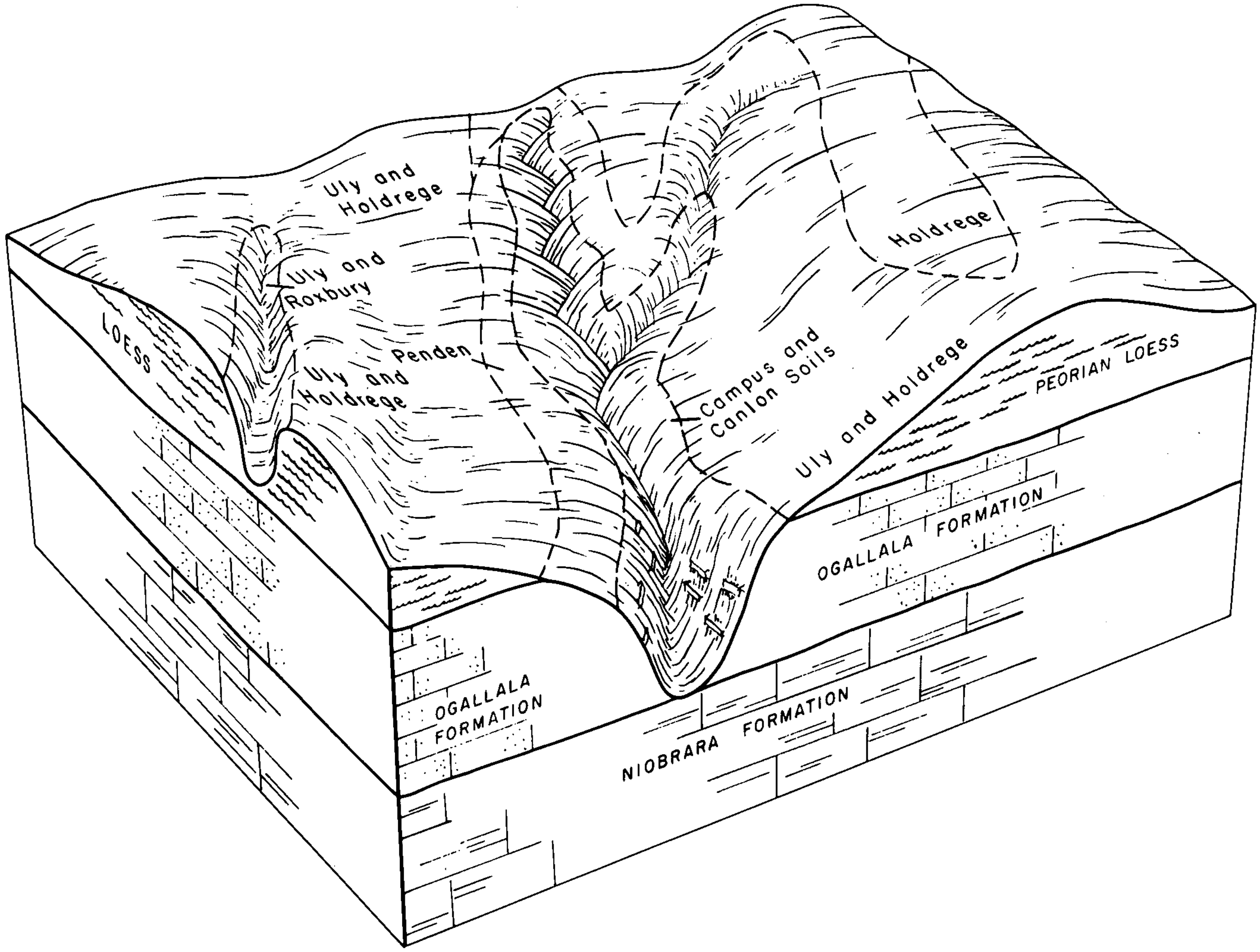

Figure 2.—**Pattern of soils and underlying material in the Uly-Holdrege-Campus association.**

These soils are best suited to use as range because of slope and soil depth (fig. 3). Most areas are in native grass pasture used as range for beef cattle. Some of the less sloping areas are used for cultivated crops. Winter wheat, legumes, and grain and forage sorghums grow well on Holdrege and Uly soils. Native grasses are in most areas of Campus and Canlon soils. Most of the areas of strongly sloping to steep Campus-Canlon soils on uplands are in native grasses. Most areas of eroded, sloping and strongly sloping Holdrege soils on uplands have been reseeded to native grasses.

The main concerns of management are controlling erosion and soil blowing and maintaining tilth and fertility.

2. *Holdrege-Uly-Nuckolls association*

Deep, gently sloping to steep, well drained, silty soils that formed in loess on uplands

This association consists of loess-covered uplands on broad divides. The soils are mostly gently sloping to strongly sloping, but they are steep in places where drainageways dissect the uplands.

This association makes up about 10 percent of the county and is in the northern part. It is about 40 percent Holdrege soils, 25 percent Uly soils, 20 percent Nuckolls soils, and 15 percent minor soils (fig. 4).

Holdrege soils are gently sloping to strongly sloping. They are on broad upland divides. The surface layer is typically grayish brown silt loam about 10 inches thick. The subsoil is friable, grayish brown and pale brown silty clay loam. It is underlain by very pale brown, calcareous silt loam loess at a depth of about 28 inches.

Uly soils are strongly sloping to steep. They are on slightly convex side slopes. The surface layer is typically grayish brown silt loam about 8 inches thick. The subsoil is friable, light brownish gray heavy silt loam. Very pale brown, calcareous silt loam is at a depth of about 28 inches.

Nuckolls soils are sloping to strongly sloping. They

are on slightly convex side slopes. The surface layer is typically dark grayish brown silt loam about 10 inches thick. The subsoil is friable, pinkish gray and light brown light silty clay loam and heavy silt loam. Light brown silt loam loess is at a depth of about 30 inches.

Of minor extent in this association are Campus, Canlon, Harney, Roxbury, and Wakeen soils. Canlon soils are sloping to steep and shallow over caliche. They are in areas along entrenched upland drainageways. Harney soils are nearly level to gently sloping and are on uplands. They have a subsoil of silty clay loam forming in loess. Roxbury soils are on the floors of narrow upland drainageways. Campus and Wakeen soils are sloping to moderately steep and moderately deep over caliche and soft chalky sediments. They are on side slopes along entrenched upland drainageways.

The available water capacity is high. The content of organic matter is high except where the sloping soils have been eroded.

The soils have a potential for all cultivated crops grown in the county, but the sloping soils are better suited to native grasses. About half of this association is used for cultivated crops. Winter wheat, sorghums, and grasses grow well on the gently sloping to strongly sloping soils. Native grasses grow on the strongly sloping, moderately deep, and deep soils. The steep areas along entrenched upland drainageways and moderately deep soils are in native grass pasture used as range. Most of the sloping and strongly sloping, eroded soils have been seeded to native grasses. The main enterprises are growing cash crops and feeding beef cattle.

The main concerns of management are controlling erosion, conserving soil moisture, and maintaining tilth and fertility.

3. *Roxbury-McCook-Hord association*

Deep, nearly level, well drained, silty soils that formed in alluvium on lowlands

This association consists of mostly nearly level soils on benches or terraces along streams and alluvial flood plains of streams and drainageways. In places slopes are steep and short between the benches and flood plains.

This association makes up about 7 percent of the county. It is about 40 percent Roxbury soils, 25 percent McCook soils, 15 percent Hord soils, and 20 percent minor soils (fig. 5).

Roxbury soils are nearly level. They are on flood plains. The surface layer is typically gray and dark gray silt loam about 30 inches thick. The subsoil is friable, grayish brown light silty clay loam. Very pale brown heavy silt loam is at a depth of about 50 inches.

McCook soils are nearly level. They are on terraces and flood plains. The surface layer is typically grayish brown coarse silt loam about 10 inches thick and slightly darkened with organic matter. The subsurface layer is light brownish gray coarse silt loam. Light

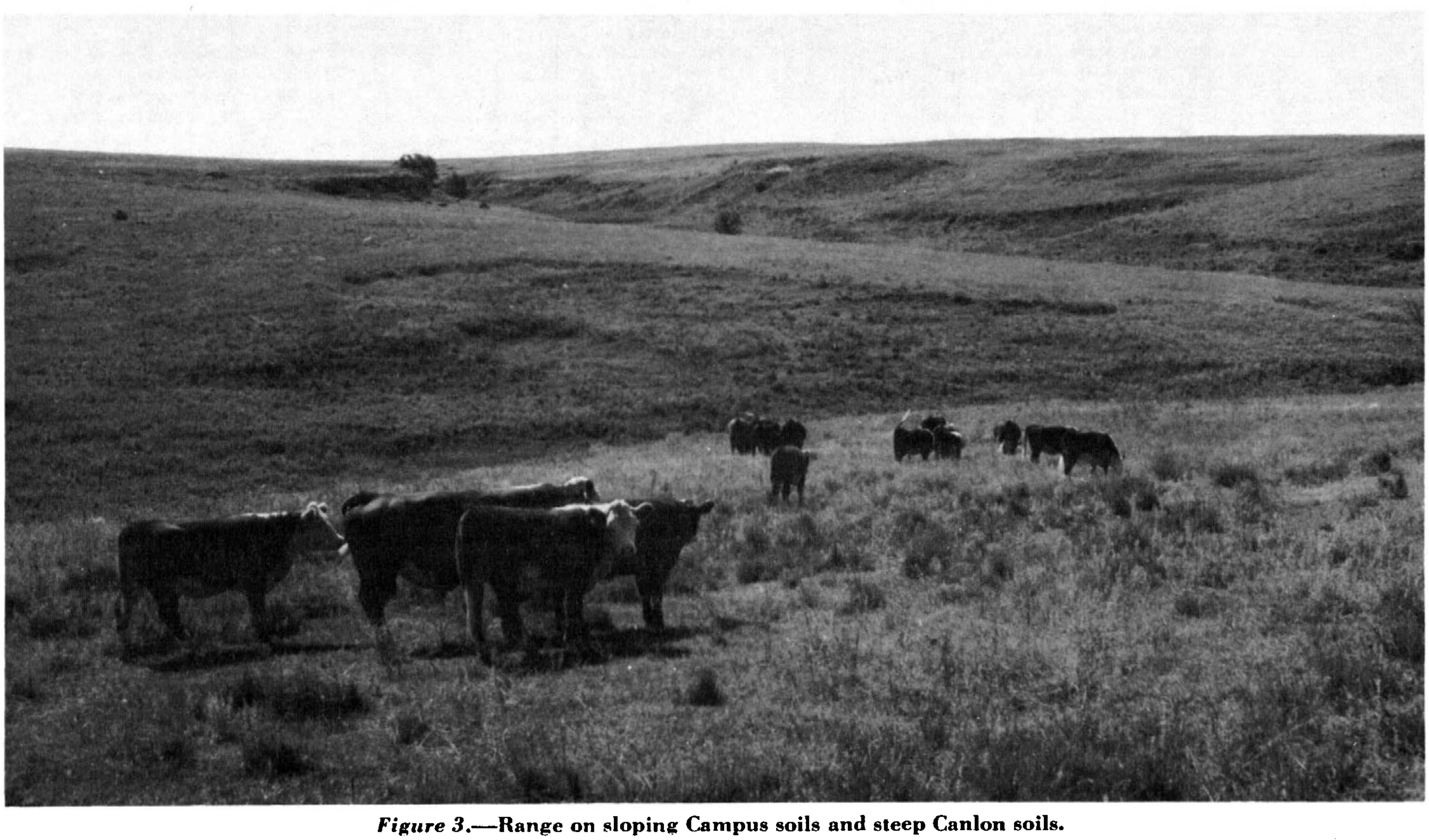

Figure 3.—**Range on sloping Campus soils and steep Canlon soils.**

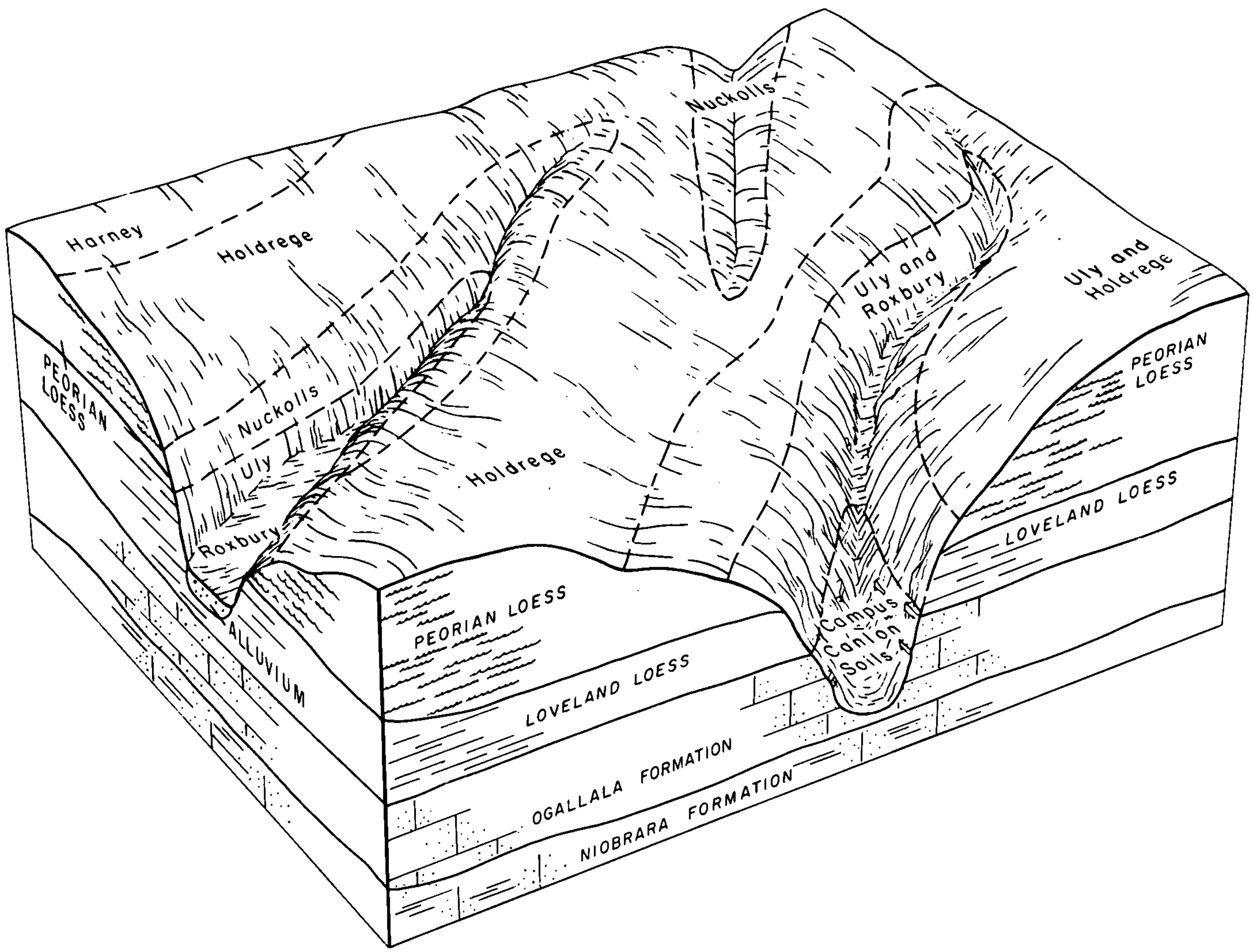

Figure 4.—**Pattern of soils and underlying material in the Holdrege-Uly-Nuckolls association.**

gray, calcareous silt loam is at a depth of about 18 inches.

Hord soils are nearly level. They are on benches or terraces. The surface layer is typically gray silt loam about 15 inches thick. The subsoil is friable, grayish brown heavy silt loam. Light brownish gray, calcareous heavy silt loam is at a depth of about 42 inches.

Of minor extent in this association are Inavale, Munjor, New Cambria, and Roxbury soils and Alluvial land, loamy. Inavale soils are duny and very sandy and are on undulating side slopes. Munjor soils are on flood plains. They are moderately sandy and loamy. Roxbury soils are on the low flood plain and are subject to frequent flooding. Alluvial land, loamy, is along the stream and has deep entrenched drainage channels. It is subject to frequent flooding. New Cambria soils are nearly level and are on terraces. They are calcareous and clayey.

The available water capacity is high in soils of this association. Fertility is also high. The content of organic matter is high in Hord and Roxbury soils.

The soils of this association have high potential for all cultivated crops commonly grown in the county. Most areas are used for cultivated crops. Corn, sorghums, small grains, and alfalfa grow well on these soils. About half of the acreage is irrigated, many areas by irrigation ditch and numerous wells. The main enterprises are growing cash crops, such as corn and winter wheat, and forage crops for livestock.

The main concerns of management are maintaining tilth and fertility; but where soils are irrigated, land leveling is needed for better management of water.

4. *Harney-Holdrege-Hord association*

Deep, nearly level to strongly sloping, well drained, silty soils that formed in loess on uplands and alluvium on terraces

This association consists of soils on loess-covered uplands and benches and on terraces along streams. It is mostly gently sloping but is nearly level to strongly sloping along large entrenched drainageways in the

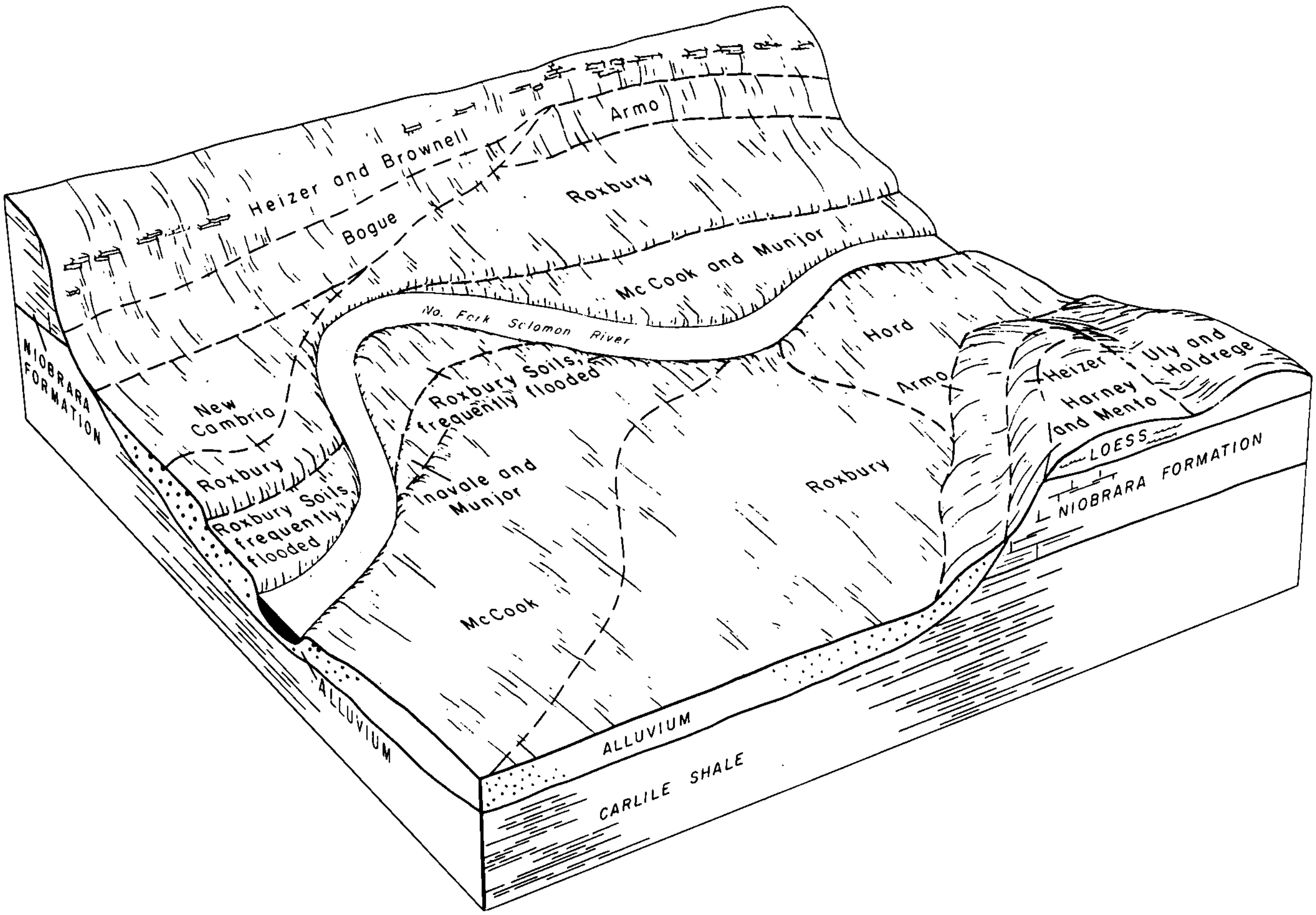

Figure 5.—**Pattern of soils and underlying material in the Roxbury-McCook-Hord association and adjacent soils on uplands.**

uplands. The gentle slopes are generally long, and the steep slopes are short.

This association makes up about 30 percent of the county. It is about 40 percent Harney soils, 35 percent Holdrege soils, 5 percent Hord soils, and 20 percent minor soils (fig. 6).

Harney soils are nearly level to sloping. They are on the broad divides of loess-covered uplands. The surface layer is typically dark grayish brown silt loam about 8 inches thick. The subsoil is dark grayish brown, friable silty clay loam in the upper part and grayish brown and light brownish gray, firm heavy silty clay loam in the middle part. The lower part is pale brown, friable silty clay loam. Very pale brown, calcareous light silty clay loam is at a depth of 28 inches.

Holdrege soils are gently sloping to strongly sloping. They are on convex side slopes of loess-covered uplands. The surface layer is typically grayish brown silt loam about 10 inches thick. The subsoil is friable, grayish brown and pale brown silty clay loam. Very pale brown, calcareous silt loam is at a depth of about 28 inches.

Hord soils are nearly level. They are on terraces or benches along streams. The surface layer is typically gray silt loam about 15 inches thick. The subsoil is friable, grayish brown heavy silt loam. Light brownish gray, calcareous heavy silt loam is at a depth of about 42 inches.

Of minor extent in this association are Alluvial land, loamy, and Nuckolls, Roxbury, Uly, and Wakeen soils. Alluvial land, loamy, is on flood plains that have entrenched stream channels. It is frequently flooded. Nuckolls soils are sloping and are on uplands. They are silt loams and have brown underlying layers. Roxbury soils are on terraces or benches and on floors of upland drainageways. They formed in deep silty alluvium. Uly soils are strongly sloping to steep and are along entrenched drains on the loess-covered uplands. Wakeen soils are moderately deep over soft chalky sediments. They are sloping to moderately steep and are along drainageways in the uplands.

The available water capacity is high. Fertility and the content of organic matter are high.

These soils have high potential for all cultivated crops commonly grown in the county. Most of this association is used for cultivated crops. Winter wheat, corn, sorghums, and hay grow well on these soils (fig. 7). Small areas are used for permanent pasture and wildlife habitat. The minor soils of the lowlands and

steep uplands are mostly in native grass pasture used as range. The main enterprises are growing cash crops and feed crops and feeding beef cattle.

The main concerns of management are controlling erosion, conserving soil moisture, and maintaining tilth and fertility.

5. *Holdrege-Wakeen-Roxbury association*

Deep and moderately deep, nearly level to moderately steep, well drained, silty soils that formed in loess and chalky shale on uplands and loamy alluvium on lowlands

This association consists of gently sloping to moderately steep soils on uplands and nearly level soils along the streams. The slopes are steepest along streams and along the large entrenched upland drainageways. The soils formed in loess and in soft chalky shale on uplands and in deep loamy alluvium along streams.

This association makes up about 30 percent of the county. It is about 40 percent Holdrege soils, 20 percent Wakeen soils, 10 percent Roxbury soils, and 30 percent minor soils (fig. 8).

Holdrege soils are deep and gently sloping to strongly sloping. They occupy convex side slopes of loess-covered uplands. The surface layer is typically grayish brown silt loam about 10 inches thick. The subsoil is friable, grayish brown and pale brown silty clay loam. Very pale brown, calcareous silt loam is at a depth of about 28 inches.

Wakeen soils are sloping to moderately steep and moderately deep. They are on convex side slopes. They formed in loess over chalky shale. The surface layer is dark grayish brown silt loam about 9 inches thick. The subsoil is friable, grayish brown silty clay loam in the upper 6 inches and is friable, very pale brown light silty clay loam in the lower 19 inches. Soft chalky shale is at a depth of 34 inches.

Roxbury soils are deep and nearly level. They are on terraces and flood plains of streams. The surface layer is gray and dark gray silt loam about 30 inches thick. The subsoil is friable, grayish brown light silty

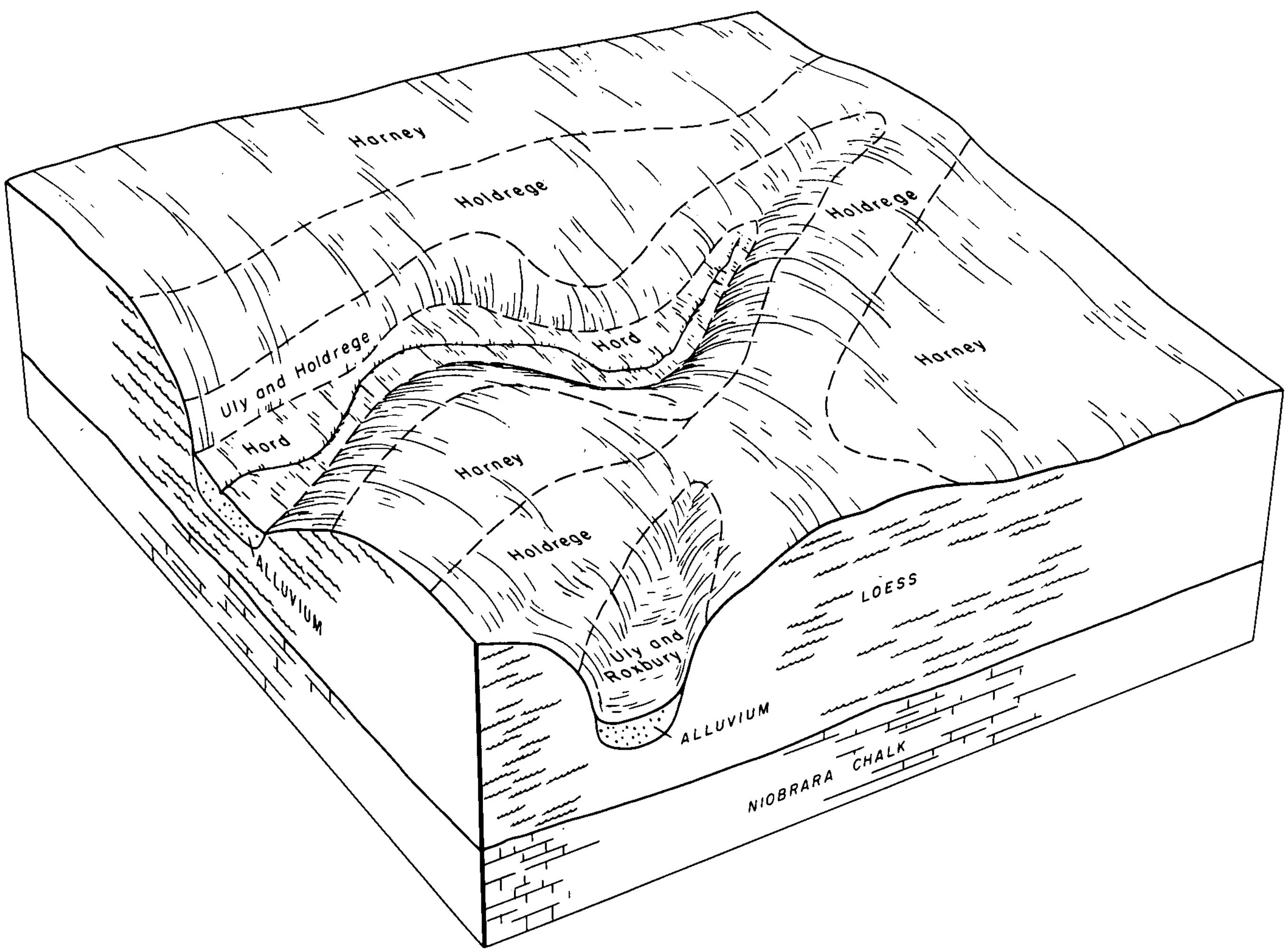

Figure 6.—**Pattern of soils and underlying material in the Harney-Holdrege-Hord association.**

Figure 7.—**Harvesting wheat on the contour on gently sloping Holdrege soils.**

clay loam. Very pale brown heavy silt loam is at a depth of about 50 inches.

Of minor extent in this association are Alluvial land, loamy, and Armo, Harney, Nuckolls, Penden, and Uly soils. Alluvial land, loamy, is on flood plains that have entrenched stream channels. The areas are frequently flooded. Armo soils are sloping and are on fans and foot slopes. Harney soils are nearly level to gently sloping and are on uplands. They have a subsoil of silty clay loam. Nuckolls soils are on side slopes. They have a subsoil of silty clay loam and a light brown underlying layer. Penden soils are sloping and are on loamy uplands. They have a calcareous underlying layer. Uly soils are strongly sloping to steep and are on uplands. They are deep, friable silt loams.

The available water capacity is high, except in Wakeen soils where it is moderate. Fertility and the content of organic matter are medium or high where the surface layer has not been eroded.

Much of this association is used for cultivated crops. Winter wheat, sorghums, alfalfa, and native grasses grow well on the gently sloping to strongly sloping soils. The more sloping, moderately deep soils are mostly in native grass pasture used as range, and they are suitable for wildlife habitat. Some sloping to strongly sloping eroded areas have been seeded to native grasses. The main enterprises are growing cash crops and feed grains and sorghum and feeding beef cattle.

The main concerns of management are controlling erosion, conserving soil moisture, and maintaining tilth and fertility.

6. Harney-Mento-Brownell association

Deep and moderately deep, nearly level to strongly sloping, well drained, silty to gravelly loamy soils that formed in loess and chalky limestone on uplands

This association consists of nearly level to sloping soils on broad divides of uplands and strongly sloping drainageways. The soils formed in loess and material derived from soft limestone. Small depressions are scattered throughout the nearly level uplands.

This association makes up about 15 percent of the county and is mostly in the southern part. It is about 50 percent Harney soils, 20 percent Mento soils, 15 percent Brownell soils, and 15 percent minor soils (fig. 9).

Harney soils are nearly level to sloping. They are on the broad divides of the uplands. The surface layer is typically dark grayish brown silt loam about 8 inches thick. The subsoil is dark grayish brown, friable silty clay loam in the upper part; grayish brown and light brownish gray, firm heavy silty clay loam in the middle part; and pale brown, friable silty clay loam in the lower part. It is underlain by very pale brown, cal-

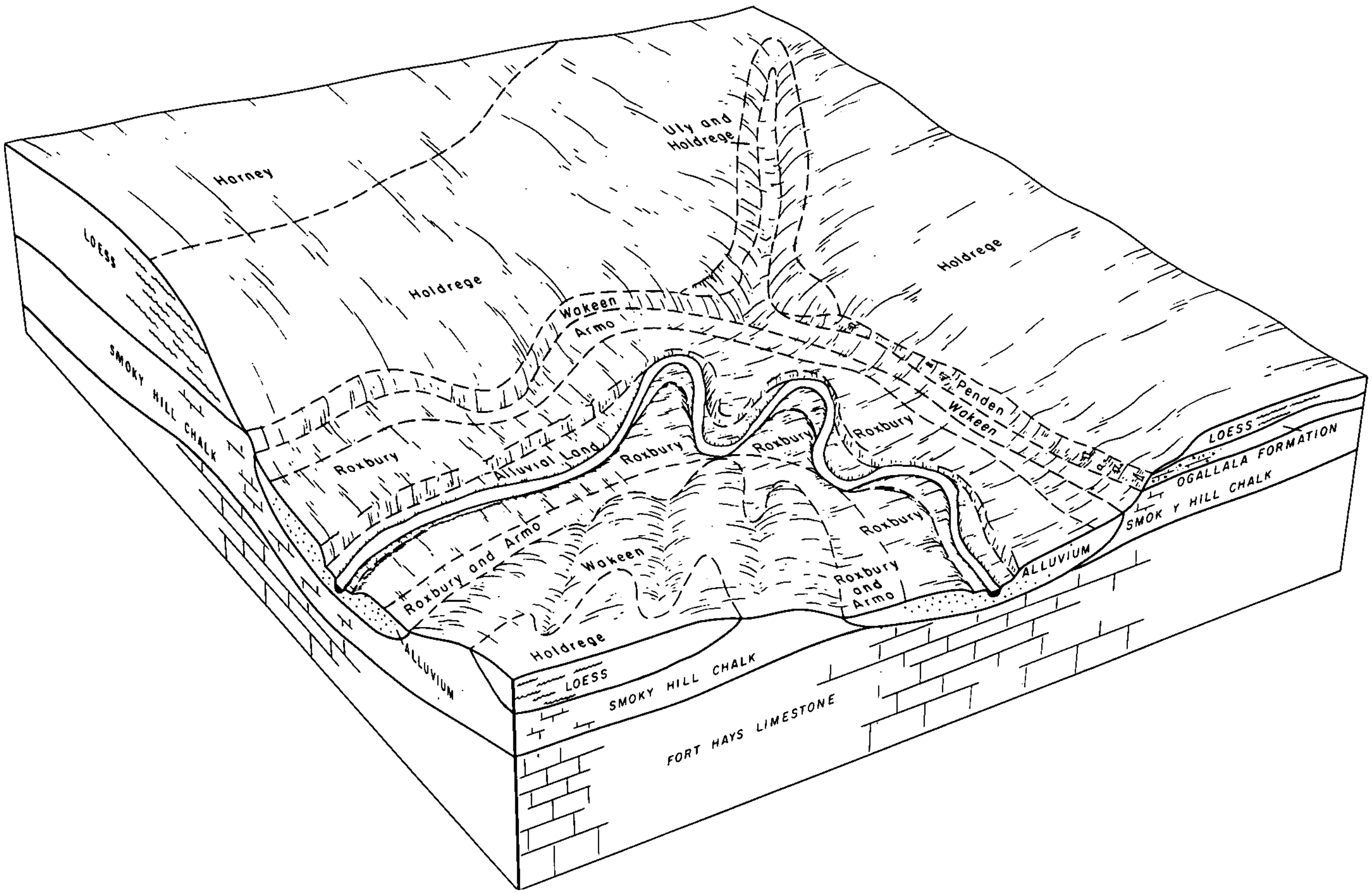

Figure 8.—**Pattern of soils and underlying material in the Holdrege-Wakeen-Roxbury association.**

careous light silty clay loam at a depth of about 28 inches.

Mento soils are on sloping uplands where the loess is thinner over limestone. They are in a complex with Harney soils. The surface layer is typically grayish brown silt loam about 8 inches thick. The subsoil is dark grayish brown and pale brown silty clay loam. It is very firm in the upper part and friable in the lower part. The subsoil is underlain by pale brown, calcareous light silty clay loam at a depth of about 32 inches.

Brownell soils are sloping to strongly sloping and are moderately deep over soft chalky limestone. They are on side slopes. The surface layer is typically gray gravelly loam about 7 inches thick. The subsoil is firm, grayish brown very gravelly loam about 9 inches thick. The underlying material is very pale brown channery loam that has coarse fragments of limestone. Chalky limestone is at a depth of about 30 inches.

Of minor extent in this association are Alluvial land, loamy, and Armo, Heizer, Holdrege, Nuckolls, Roxbury, and Wakeen soils. Armo soils are deep and loamy and are on foot slopes and fans. Heizer soils are shallow over limestone. Holdrege soils are sloping and are on uplands. They have a subsoil of friable silty clay loam that formed in loess. Nuckolls soils are sloping and are on uplands. They have a light brown underlying layer. Roxbury soils and Alluvial land, loamy, are on the lowlands. They are frequently flooded. Wakeen soils are moderately deep, sloping to moderately steep, and formed in chalky shale on uplands.

The available water capacity is high in all soils of the association. Fertility and the content of organic matter are high in Harney and Mento soils and low in Brownell soils.

Harney and Mento soils are suited to all cultivated crops commonly grown in the county. Winter wheat and other small grains, sorghums, and alfalfa grow well on them. Most of the nearly level to gently sloping soils of this association are used for cultivated crops. Most of the sloping and strongly sloping soils are in native grass range. Brownell soils are almost always in native grasses. The main enterprises are growing cash crops and feed for livestock and raising cows.

The main concerns of management are controlling erosion, conserving soil moisture, and maintaining tilth and fertility.

7. *Heizer-Armo-Bogue association*

Shallow to deep, sloping to steep, somewhat excessively drained to moderately well drained, gravelly loamy, loamy, and clayey soils that formed in chalky limestone, alluvium, and clayey shale on uplands

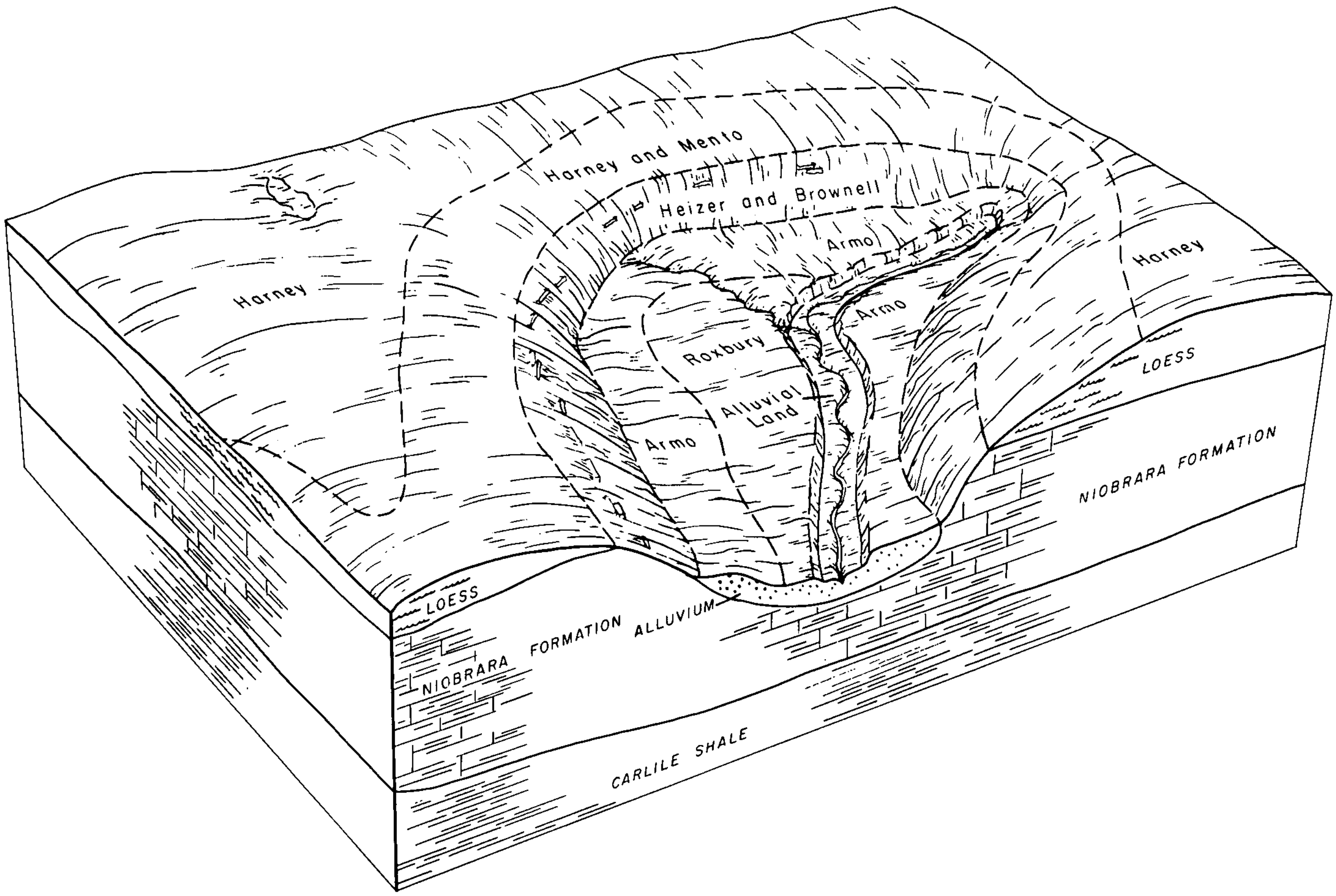

Figure 9.—**Pattern of soils and underlying material in the Harney-Mento-Brownell association.**

This association consists of sloping to steep soils on uplands. The soils formed in material weathered from limestone and clayey shales and in loamy alluvium. Barren shale outcrops are exposed in areas of Bogue soils, outcrops of limestone are in areas of Heizer soils, and gravelly areas are in Armo soils.

This association makes up about 4 percent of the county and is in the southeastern and south-central parts. It is about 40 percent Heizer soils, 30 percent Armo soils, 10 percent Bogue soils, and 20 percent minor soils (fig. 10).

Heizer soils are strongly sloping to steep and are somewhat excessively drained. They are in a complex with Brownell soils on side slopes below the upland divides. The surface layer is typically gray gravelly loam about 8 inches thick. The underlying material is grayish brown channery loam. Hard, chalky limestone is at a depth of 14 inches.

Armo soils are sloping, calcareous, and well drained. They are generally on fans below Heizer soils. The surface layer is typically dark gray and grayish brown loam about 12 inches thick. The subsoil is friable, light brownish gray heavy loam about 12 inches thick. The underlying material is light gray loam and gravelly loam that contains many fragments of rounded limestone pebbles.

Bogue soils are sloping to strongly sloping and are moderately well drained. The surface layer is typically gray clay about 6 inches thick. The subsoil is extremely firm, gray clay about 14 inches thick. The underlying material is gray clay that contains small yellowish brown shale fragments. Clay shale is at a depth of 32 inches.

Of minor extent in this association are Brownell, Harney, Mento, New Cambria, Roxbury, and Wakeen soils, and Alluvial land, loamy. Harney and Mento soils are gently sloping to sloping and are on the loess-covered upland divides. Brownell soils are intermingled with areas of Heizer soils. New Cambria soils are nearly level and formed in clayey alluvium. Wakeen soils are sloping and are moderately deep over chalky shale. They are on uplands. Roxbury soils formed in silty alluvium on terraces and flood plains.

The available water capacity is high in Armo soils, moderate in Bogue soils, and very low in Heizer soils. Fertility is high in Armo soils and low in Bogue and Heizer soils.

Most of this association is used for range and wild-

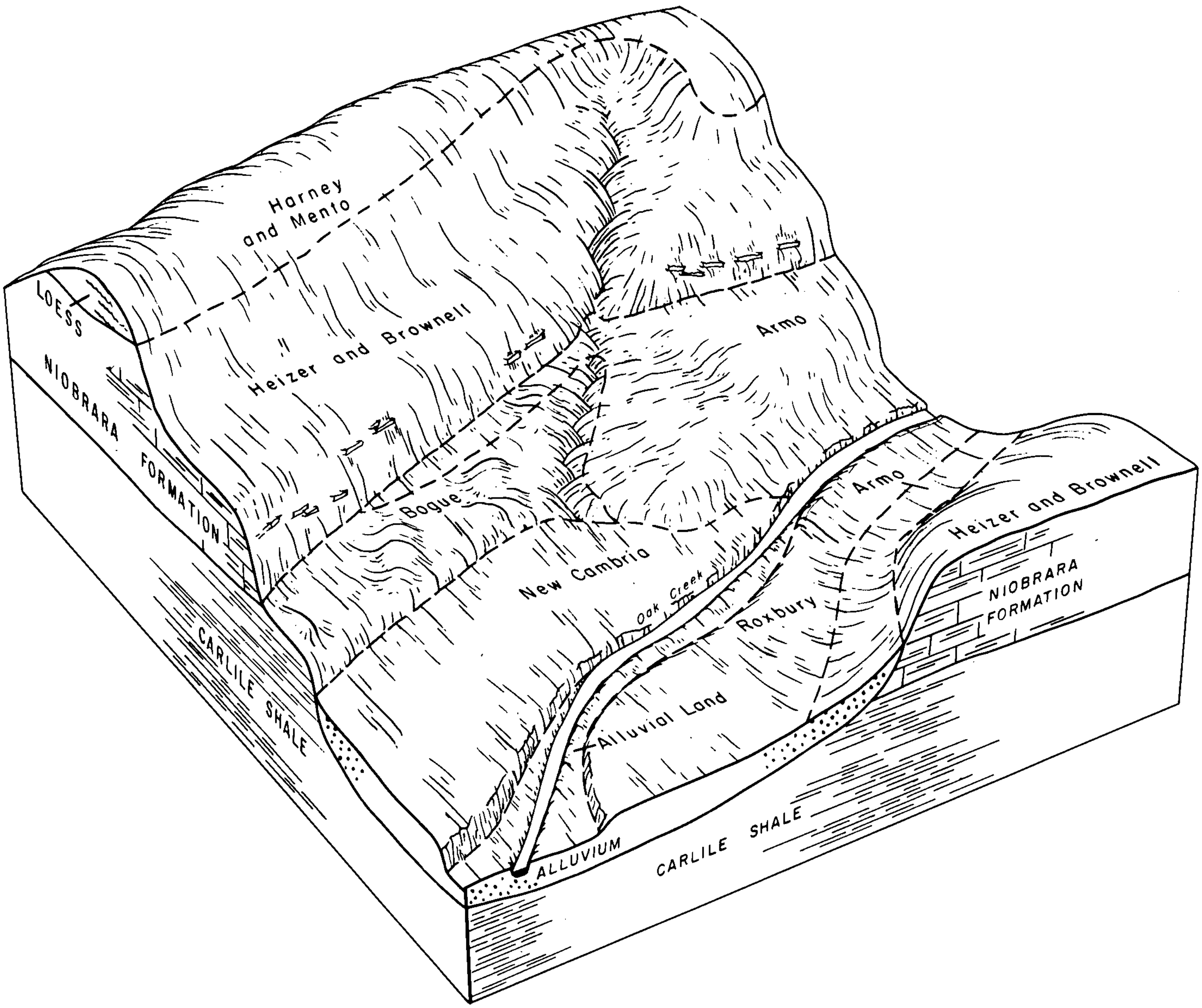

Figure 10.—**Pattern of soils and underlying material in the Heizer-Armo-Bogue association.**

life habitat, but the sloping Armo soils are used for cultivated crops. Small grains, sorghums, and hay grow well on Armo soils. Native grasses grow best on Heizer and Bogue soils. The main enterprises are raising beef cattle and growing cash crops and feed crops for beef cattle.

The main concerns of management are controlling erosion, conserving soil moisture, proper grazing, and maintaining tilth and fertility.

Descriptions of the Soils

This section describes each soil series in detail and then, briefly, each mapping unit in that series. Unless stated otherwise, what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface down to rock or other underlying material. Each series has two descriptions of the profile. The first is brief and in terms familiar to a layman. The second is more detailed and is for those who need to make thorough and precise studies of soils. The profile described in the series is representative of mapping units in that series. If the profile of a given mapping unit is different from the one described for

the series, these differences are stated in describing the mapping unit, or they are differences that are apparent in the name of the mapping unit. Color terms are for dry soil unless otherwise stated.

Preceding the name of each mapping unit is a symbol that identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit, range site, and windbreak group in which the mapping unit has been placed. The capability unit, range site, and windbreak group for each soil is listed in the "Guide to Mapping Units" at the back of this survey.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Alluvial land, loamy, for example, does not belong to a soil series, nevertheless it is listed in alphabetic order along with the soil series.

Small areas of contrasting soils or special features, such as rock outcrops, that affect the use of soils are shown on the soil map by spot symbols. The spot symbols that are used are listed on the legend sheet under "Conventional Symbols." The spot symbols that have been used on the maps of Smith County are discussed in the following paragraphs.

Severely eroded spot. Each symbol for a severely eroded spot represents an area 2½ acres or less in size. Crop growth is poor in these spots because fertility is low and tilth is poor. If clayey material has been exposed by erosion, tillage is difficult and a good seedbed is difficult to prepare. If soil material that is high in lime has been exposed, iron chlorosis can affect grain sorghums.

Small depressions. Each symbol represents an area as much as 2½ acres in size. Crop growth during wet seasons is hampered by too much water. In a few areas, crops are damaged by excessive amounts of water. In a dry season, crops do at least as well in depressions as in areas that have better drainage. Most of the soils in depressions are wetter than the surrounding soils.

Rock outcrops. Each symbol represents an area 2½ acres or less in size. Rock outcrops are shown in areas of moderately deep or deep soils that do not generally have outcrops of bedrock. Rock outcrops interfere with tillage, planting, and harvesting as well as the construction of terraces and waterways.

Sand spot. Each symbol represents an area 2½ acres or less in size where crop growth during dry seasons is hampered by low moisture storage. These sandy areas are on uplands where the loess is thin.

Gravel spot. Each symbol represents an area 2½ acres or less in size where spots of limestone gravel occur on alluvial soils. These areas interfere with tillage and planting. Crop growth is somewhat restricted because of low moisture storage and high lime content. Gravel spots also interfere with land leveling.

Wind hummock. Each symbol represents an area 5 acres or less in size. These areas are very sandy and the topography is undulating and hummocky. The available water capacity is low, and soil blowing is a hazard.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*10*).[1]

Alluvial Land

Aa—Alluvial land, loamy, is a miscellaneous land type consisting of deep, friable soils that have a darkened surface layer. They are mainly on nearly level flood plains that are broken by entrenched channels of streams, and range from about 200 feet to 500 feet in width. Steep broken banks are along the low flood plains. The stream channels are 20 to 70 feet in width and 3 to 10 feet in depth, and together with nearly vertical banks they make up about 15 percent of the acreage. Because the areas are on flood plains, they are subject to frequent flooding.

[1] Italic numbers in parentheses refer to Literature Cited, p. 68.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Area	Extent
	Acres	*Percent*
Alluvial land, loamy	22,860	4.0
Armo loam, 2 to 7 percent slopes	5,350	.9
Bogue clay, 3 to 15 percent slopes	2,860	.5
Brownell gravelly loam, 3 to 15 percent slopes	14,290	2.5
Campus-Canlon complex, 5 to 30 percent slopes	4,570	.8
Harney silt loam, 0 to 1 percent slopes	17,170	3.0
Harney silt loam, 1 to 3 percent slopes	88,570	15.5
Harney-Mento silt loams, 3 to 7 percent slopes	34,860	6.1
Heizer-Brownell complex, 7 to 30 percent slopes	8,000	1.4
Holdrege silt loam, 1 to 3 percent slopes	51,340	9.0
Holdrege silt loam, 3 to 7 percent slopes	74,150	13.0
Holdrege silty clay loam, 3 to 7 percent slopes, eroded	20,130	3.5
Hord silt loam	14,290	2.5
Inavale-Munjor complex	1,440	.3
McCook silt loam	10,760	1.9
McCook-Munjor complex	2,480	.4
New Cambria silty clay	1,690	.3
Nuckolls silt loam, 7 to 12 percent slopes	34,100	6.0
Nuckolls-Holdrege silt loams, 3 to 7 percent slopes	9,280	1.6
Penden loam, 3 to 7 percent slopes	6,610	1.1
Roxbury silt loam	17,500	3.0
Roxbury silt loam, frequently flooded	13,720	2.4
Roxbury-Armo complex, 0 to 3 percent slopes	8,550	1.5
Uly-Holdrege silt loams, 7 to 12 percent slopes	30,100	5.3
Uly-Roxbury silt loams, 0 to 30 percent slopes	27,230	4.8
Wakeen silt loam, 3 to 7 percent slopes	18,290	3.2
Wakeen complex, 5 to 20 percent slopes	31,230	5.5
Total	571,520	100.0

The soils range from loam to silty clay loam and are neutral to alkaline. They are highly stratified in places and contain small limestone pebbles. In most places the surface layer is silt loam; underlying layers are stratified with coarse silt loams and loamy sediments. Generally, the soil material is more than 40 inches thick, but it ranges to more than 72 inches in the upland drainageways.

Included in mapping are areas of Roxbury silt loam, frequently flooded, and small areas of McCook-Munjor complex.

The water intake is medium, and the available water capacity is high. The depth to water is generally more than 6 feet. Surface runoff is slow to medium, depending on flooding. Frequent flooding limits the use of the soils. Erosion is a hazard and deposition of fresh sediments occurs in some places. Scouring and erosion occur in the stream channel.

The vegetation consists of tall and mid grasses on the flood plains, and most areas are still in native grass. Broadleaf trees grow along the broken slopes and channels. Alluvial land is used mainly for livestock and wildlife range (fig. 11). In places dugouts are constructed for watering of livestock.

Deferred grazing or rotation-deferred grazing can be used along with proper stocking rates to maintain or improve the vigor and composition of the grasses. Weeds can be controlled by mechanical methods or by chemicals. Watershed improvement helps control flooding. Capability unit Vw-1, dryfarmed; Loamy Lowland range site; windbreak group 1.

Armo Series

The Armo series consists of deep, well drained, moderately sloping soils on foot slopes and fans. These

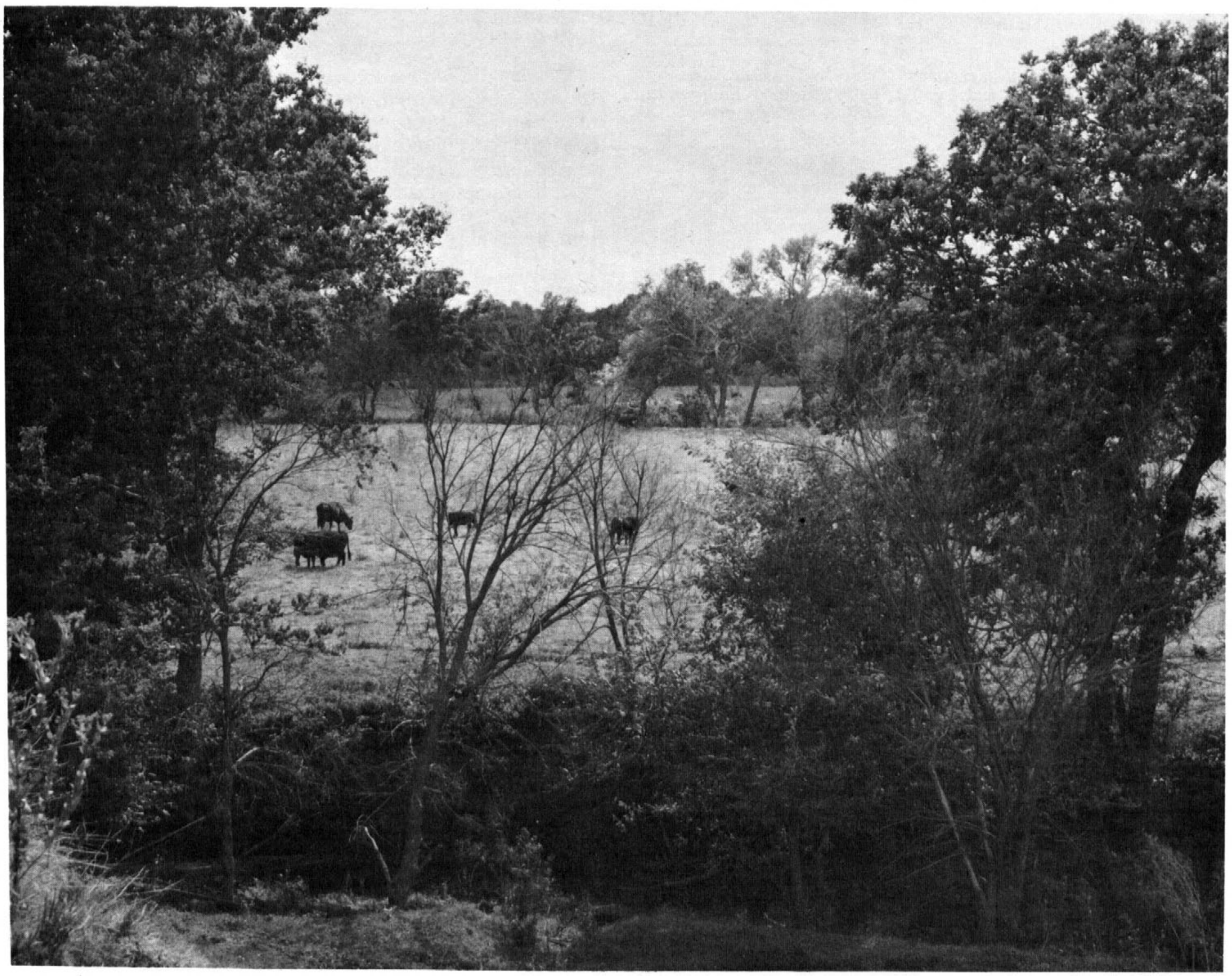

***Figure 11.*—An area of Alluvial land, loamy, in the Loamy Lowland range site.**

soils formed in loamy and gravelly alluvium and colluvium. The native vegetation was mainly mid and tall grasses.

In a representative profile the surface layer is dark gray and grayish brown loam about 12 inches thick. The subsoil is friable, heavy loam about 12 inches thick. It is light brownish gray. The underlying material is light gray loam and gravelly loam.

Permeability is moderate, and the available water capacity is high. Fertility is high. Surface runoff is medium to rapid.

Armo soils are suited to farming if conservation practices are used to reduce erosion, and they are well suited to native grasses. They are well suited to habitat for openland wildlife. The limitations for many nonfarm uses are moderate.

These soils are used for crops and range.

Representative profile of Armo loam, 2 to 7 percent slopes, in native grass, 1,200 feet west and 200 feet north of the southeast corner of sec. 28, T. 5 S., R. 12 W.

A1—0 to 8 inches, dark gray (10YR 4/1) loam, very dark gray (10 3/1) when moist; moderate medium granular structure; slightly hard, friable; many roots; few worm casts; moderate effervescence; mildly alkaline; clear wavy boundary.

A3—8 to 12 inches, grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) when moist; strong medium granular structure; slightly hard, friable; numerous roots; common small rounded limestone fragments about ¼ inch in diameter; violent effervescence; mildly alkaline; abrupt wavy boundary.

B2—12 to 24 inches, light brownish gray (10YR 6/2) heavy loam; dark grayish brown (10YR 4/2) when moist; moderate medium granular structure; slightly hard, friable; few roots; few small limestone pebbles; violent effervescence; moderately alkaline; gradual wavy boundary.

C1ca—24 to 42 inches, light gray (10YR 7/2) heavy loam, grayish brown (10YR 5/2) when moist; weak medium granular structure; very hard, friable; few fine roots; porous; common medium soft spherical carbonate accumulations; violent effervescence; moderately alkaline; gradual wavy boundary.

C2—42 to 72 inches, light gray (10YR 7/2) loam, light brownish gray (10YR 6/2) when moist; massive; slightly hard, friable; porous; few roots; small fragments of rounded limestone pebbles; violent effervescence; moderately alkaline.

The solum is mildly alkaline to moderately alkaline.

The A1 horizon is dark gray to brown and is 7 to 10 inches thick. It is typically loam, but is silt loam in places. The A3 horizon is 3 to 5 inches thick. It contains few to many rounded water-worn pebbles. The B horizon ranges from loam to light gravelly clay loam. The C horizon is gravelly loam and loam.

Armo soils are near Bogue, Penden, Roxbury, and Wakeen soils. They are not darkened as deeply as Roxbury soils and formed in more gravelly alluvium. They are more gravelly and less silty and are deeper than Wakeen soils. They have a less distinct Cca horizon than the Penden soil. Armo soils are less clayey than Bogue soils.

Ar—Armo loam, 2 to 7 percent slopes. This is a sloping soil on narrow foot slopes and fans. Areas are small to medium and somewhat irregularly shaped.

Included with this soil in mapping are small areas of gently sloping Roxbury soils in upland drainageways. Also included, and shown on the soil map by the symbol for a gravel spot, are outcroppings of gravel that are 2½ acres or less.

Surface runoff is medium to rapid, and the hazard of erosion is severe.

This soil is suited to farming if erosion is controlled. It erodes easily if not protected by careful management. The areas now cultivated are suitable for native grasses. Sorghum is likely to be affected by chlorosis because of the high lime content of the soil. There are suitable sites generally available for stock-water impoundments. Most areas of this soil are used for crops, but some are used for range.

The main concern of management is conserving soil moisture and controlling erosion. Range use, rate of stocking, deferment of grazing, and rotation of grazing help produce adequate forage for livestock.

This soil has slight to moderate limitations for recreational or urban development. Capability unit IIIe-2, dryfarmed; Limy Upland range site; windbreak group 3.

Bogue Series

The Bogue series consists of moderately deep, moderately well drained, sloping to strongly sloping soils on uplands. These soils formed in acid clayey shale. The native vegetation was mainly short and mid grasses and some oak trees.

In a representative profile the surface layer is gray clay about 6 inches thick. The subsoil is extremely firm gray clay about 14 inches thick. The underlying material is gray clay that contains yellowish brown shale fragments. Clay shale is at a depth of 32 inches.

Permeability is very slow, and the available water capacity is moderate. Fertility is low. Surface runoff is rapid. Droughtiness occurs because the soil has a high clay content and releases water slowly. The content of organic matter is low.

Bogue soils are poorly suited to crops. They are better suited to use as range because of the clay texture. They are well suited to habitat for openland wildlife. The limitations for many nonfarm uses are severe.

Most areas are in native grass range.

Representative profile of Bogue clay, 3 to 15 percent slopes, in native grass, 800 feet west and 600 feet north of the southeast corner sec. 33, T. 5 S., R. 13 W.

A1—0 to 6 inches, gray (5YR 5/1) clay, dark gray (5Y 4/1) when moist; weak medium subangular blocky structure; very hard, very firm; many fine grass roots; few fragments of small calcium carbonate concretions; slight effervescence; moderately alkaline; gradual smooth boundary.

B2—6 to 20 inches, gray (5Y 5/1) clay, very dark gray (5Y 3/1) when moist; yellowish brown (10YR 5/6) mottles on vertical faces of peds; weak coarse blocky structure; extremely hard, extremely firm; few slickenside faces intersect and inclined at 20 to 30 degrees from horizontal; slight effervescence; mildly alkaline; gradual wavy boundary.

C1—20 to 25 inches, gray (5Y 5/1) clay, dark gray (5Y 4/1) when moist; weak blocky structure breaking to moderate thin platy; extremely hard, extremely firm; few fine roots; common small shale fragments of yellowish brown (10YR 5/6) when moist; slight effervescence; thin soft carbonate films on outside of peds; slightly acid shale fragments; gradual smooth boundary.

C2—25 to 32 inches, gray (5Y 5/1) weathered clay shale that has common horizontal strata about 1 centimeter

thick of yellowish brown (10YR 5/6) and dark gray (5Y 4/1) when moist; moderate medium platy structure; extremely hard, extremely firm; very few roots; very strongly acid; gradual smooth boundary.

C3—32 to 72 inches, gray (5Y 5/1) clay shale.

The A1 horizon ranges from clay to silty clay and is 4 to 8 inches thick. It is moderately alkaline to neutral.

The B2 horizon is 8 to 14 inches thick. The depth to unweathered acid shale ranges from 20 to 40 inches. The underlying shale ranges from medium acid to very strongly acid.

Bogue soils are near Armo and New Cambria soils. Bogue soils are more clayey than New Cambria soils and are underlain by clay shale at a depth of 20 to 40 inches. Bogue soils are more clayey than Armo soils.

Bo—Bogue clay, 3 to 15 percent slopes. This is a sloping to strongly sloping soil in broad areas of erosional uplands. Individual areas are between 10 and 200 acres.

Included with this soil in mapping are small areas of Armo soils that formed in less clayey alluvium. Also included are small areas of acid clay soils 10 to 20 inches deep over shale, and small barren shale outcrops. Small areas of New Cambria soils are included in the lowlands along drainageways.

Surface runoff is rapid, and the hazard of erosion is severe. Erosion is a hazard if the soil is overgrazed. In cultivated areas soil blowing is severe.

This soil is not suited to farming because it has clayey texture and poor tilth. It is better suited to native grasses than to cultivated crops and is best suited to range.

Nearly all the acreage is used for range, but a few small areas have been cultivated. The effective root zone is 20 to 40 inches. The soil is droughty during periods of low rainfall.

Grazing should be at a rate that will maintain or improve the vigor of the most desirable grasses. Deferred grazing or rotation deferred grazing can be used, along with a proper stocking rate, to improve the vigor and composition of the grasses. If seeding is necessary, native grasses that are suited to this soil should be used. This soil has sites for dams to provide stockwater ponds (fig. 12).

This soil has severe limitations for recreational or urban developments. Capability unit VIe-5 dryfarmed; Blue Shale range site; not placed in a windbreak group.

Brownell Series

The Brownell series consists of moderately deep, well drained, sloping to strongly sloping soils on erosional uplands. These soils formed in material weathered from soft limestone. The native vegetation was mainly mid and tall grasses.

In a representative profile (fig. 13) the surface layer is gray gravelly loam about 7 inches thick. The subsoil is grayish brown friable very gravelly loam about 9 inches thick. The underlying material is very pale brown channery loam that contains many coarse fragments of soft limestone. White dense chalk lime-

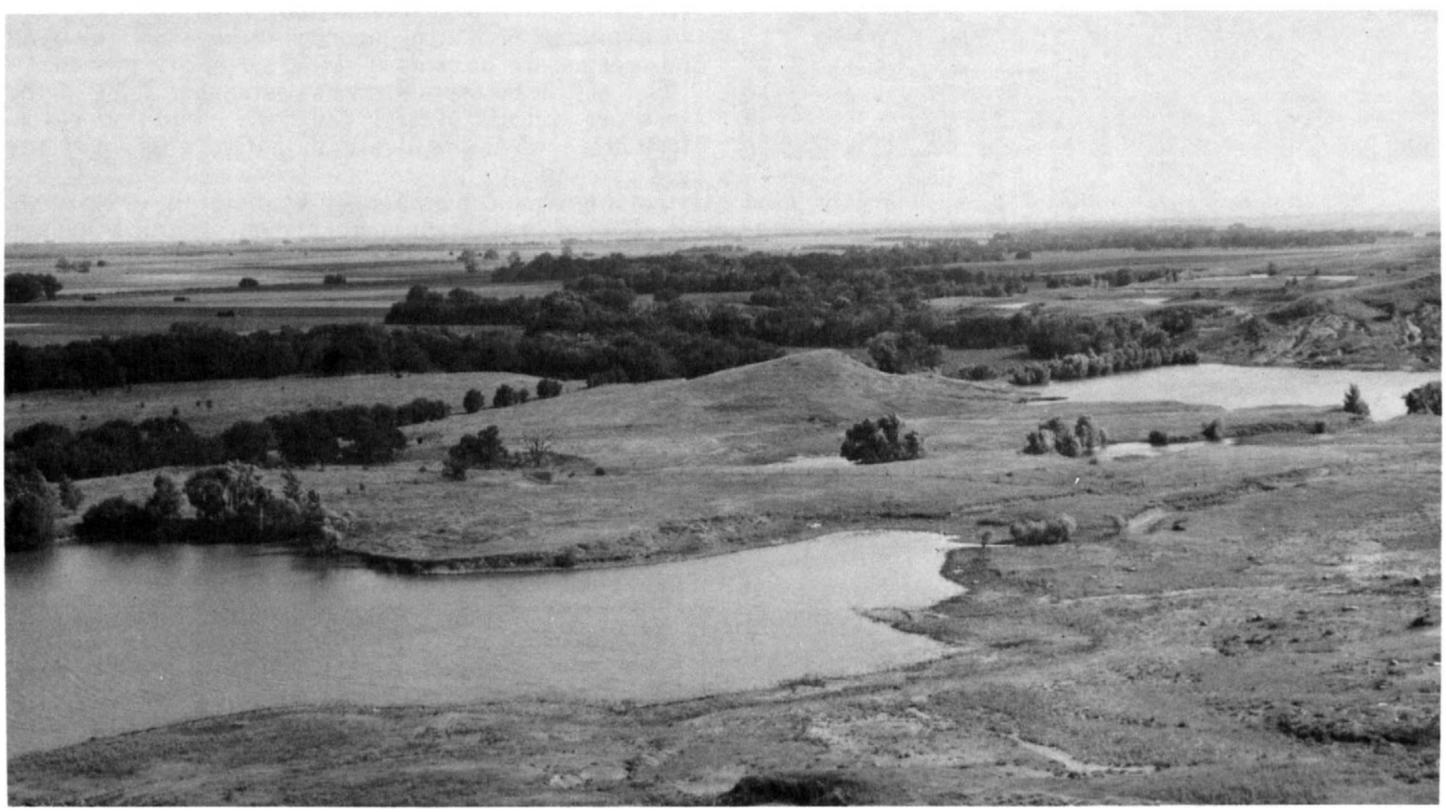

Figure 12.—**Ponds built on Bogue soils hold water for irrigation.**

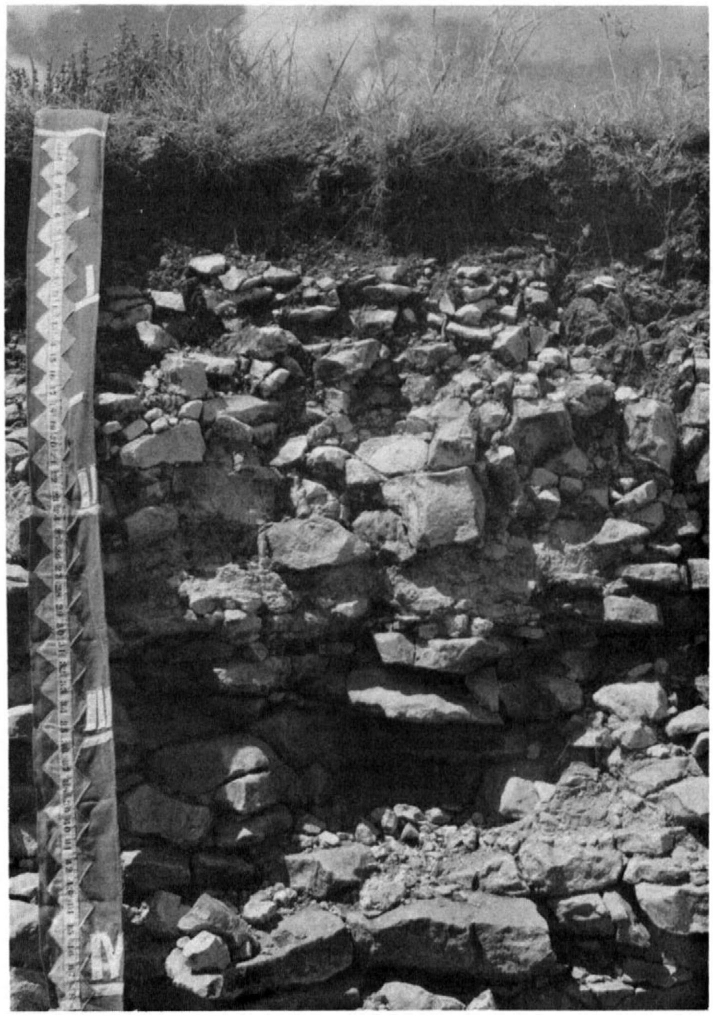

Figure 13.—Representative profile of Brownell gravelly loam, 3 to 15 percent slopes.

stone bedrock is at a depth of 30 inches.

Permeability is moderate, and the available water capacity is low. Fertility is low. Surface runoff is medium. Effective root depth is moderately shallow. These are productive rangeland soils.

Brownell soils are best suited to native grasses used as range and are generally poorly suited to crops. They are well suited to habitat for openland wildlife. The limitations for many nonfarm uses are moderate to severe.

Most areas are used as range.

Representative profile of Brownell gravelly loam, 3 to 15 percent slopes, in native grass, 600 feet north and 50 feet west of the southeast corner of sec. 9, T. 5 S., R. 13 W.

A1—0 to 7 inches, gray (10YR 5/1) gravelly loam, very dark gray (10YR 3/1) when moist; moderate fine granular structure; slightly hard, friable; many fine roots; many worm casts; strong effervescence; moderately alkaline; gradual smooth boundary.

B2—7 to 16 inches, grayish brown (10YR 5/2) very gravelly loam, very dark grayish brown (10YR 3/2) when moist; moderate fine granular structure; slightly hard, friable; many fine roots; numerous common worm casts; many fragments of chalky limestone 1 to 2 inches in diameter make up about 50 percent of the mass; strong effervescence; moderately alkaline; gradual wavy boundary.

C—16 to 30 inches, very pale brown (10YR 8/4) channery loam, very pale brown (10YR 7/3) when moist; weak granular structure; slightly hard, friable; few fine roots; few worm casts; many coarse fragments of soft limestone 2 to 3 inches in diameter make up 70 percent of the mass, and loamy sediments fill interstices; strong effervescence; moderately alkaline; gradual smooth boundary.

R—30 inches, white (10YR 8/2) chalky limestone.

The solum is mildly alkaline to moderately alkaline throughout. The depth to limestone bedrock ranges from 20 to 40 inches.

The A1 horizon is gray to grayish brown silt loam to gravelly loam and is 4 to 9 inches thick. The B2 horizon is gray to grayish brown. The amount and size of limestone fragments increase with depth.

Brownell soils are near Heizer and Wakeen soils and occupy positions similar to those of Campus and Canlon soils. Brownell soils are deeper over bedrock than Heizer and Canlon soils. They are underlain by hard limestone, while Campus soils are underlain by soft caliche and Wakeen soils are underlain by soft chalky shale.

Br—Brownell gravelly loam, 3 to 15 percent slopes. This is a sloping to strongly sloping soil mostly on small hills, low ridges, and side slopes of drainageways in the uplands.

Included with this soil in mapping are small areas of steep Heizer soils. Also included are small areas of sloping Armo soils on the uplands below Brownell soils.

Surface runoff is medium. Root zone is limited, and the available moisture capacity is low. Soil blowing and erosion are hazards if the grass is overgrazed.

This soil is best suited to use as range. Some of the areas are sources of rock for use in building roads. Most areas of this soil are in native grass and are used as range.

Grazing should be managed to maintain or improve the cover of grass. Good management practices include rotation, deferment, distribution of grazing, and reseeding of native grasses. Sites for dams are in drainageways that were included in this mapping unit.

This soil has moderate to severe limitations for recreational or urban developments. Capability unit VIe-4, dryfarmed; Limy Upland range site; windbreak group 3.

Campus Series

The Campus series consists of moderately deep, well drained, sloping and strongly sloping soils on uplands. These soils formed in partly consolidated soft caliche sediments. The native vegetation was mainly mid and short grasses.

In a representative profile the surface layer is grayish brown loam about 8 inches thick. The subsoil is grayish brown, friable light loam about 10 inches thick. The underlying material is light gray light loam that contains many fragments of soft caliche. Soft caliche is at a depth of 32 inches.

Permeability and the available water capacity are

moderate. Fertility is medium. Surface runoff is medium to rapid.

Campus soils are not well suited to cultivated crops. They are highly susceptible to erosion if they are cultivated. These soils are generally better suited to native grasses used as range. They are well suited to habitat for openland wildlife. Their limitations for many nonfarm uses are moderate.

Most areas of these soils are used for native grasses.

Representative profile of Campus loam, in an area of Campus-Canlon complex, 5 to 30 percent slopes, in native grass, about 2,000 feet west and 400 feet north of the southeast corner of sec. 9, T. 1 S., R. 15 W.

A1—0 to 8 inches, grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; slightly hard, friable; many fine roots; few worm casts; slight effervescence; mildly alkaline; clear smooth boundary.

B2—8 to 18 inches, grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) when moist; moderate medium granular structure; slightly hard, friable; many fine roots; common fragments of soft caliche; strong effervescence; moderately alkaline; gradual smooth boundary.

C1ca—18 to 32 inches, light gray (10YR 7/2) light loam, light brownish gray (10YR 6/2) when moist; weak granular structure; hard, friable; numerous roots; violent effervescence; soft caliche makes up about 25 percent of the mass; mildly alkaline; clear smooth boundary.

C2—32 to 72 inches, white (10YR 8/2) partly consolidated soft caliche.

The solum is mildly alkaline to moderately alkaline. The depth to soft caliche ranges from 20 to 40 inches. The depth to the C1ca horizon is less than 24 inches, and the calcium carbonate content of this horizon is greater than 25 percent.

The A1 horizon ranges from dark grayish brown to brown when dry and is very dark grayish brown or slightly lighter when moist. It ranges from silt loam to sandy loam with loam as the dominant texture. The A1 horizon is 5 to 10 inches thick. The B2 horizon ranges from loam to light clay loam.

Campus soils were mapped only with Canlon soils. Campus soils are near Canlon and Penden soils, and occupy positions similar to those of Brownell soils. Campus soils are deeper over caliche than Canlon soils. They have a higher carbonate content than Penden soils. They are underlain by soft caliche, while Brownell soils are underlain by hard limestone.

Cc—Campus-Canlon complex, 5 to 30 percent slopes. The soils of this complex are in small to medium areas on the sides and ridges of erosional uplands. Campus soils are deeper to bedrock than Canlon soils. This complex is about 70 percent sloping to strongly sloping Campus loam, 20 percent strongly sloping to steep Canlon loam and rock outcrops, and 10 percent Penden loam.

Runoff is rapid on Canlon soils and less rapid on the smoother Campus soils.

These soils are not well suited to cultivation, but they are well suited to use as range. Nearly all of this complex is in native grass range. Rocks outcrop on the steep slopes of Canlon soils.

The main concerns of management are erosion and runoff caused by severe rainstorms and the moderate to very low available water capacity. If the native grass is well managed, good yields of forage are obtained.

Grazing must be carefully controlled for high production of forage. Rotation grazing should be practiced to maintain a good cover of grass, increase the intake of water, and conserve more soil moisture.

There are sites for dams and ponds in places. Material for surfacing roads is obtained in places from the substratum. Capability unit VIe-2, dryfarmed; Campus soils in Limy Upland range site and windbreak group 3; Canlon soils in Shallow Limy range site and no windbreak group.

Canlon Series

The Canlon series consists of shallow, somewhat excessively drained, strongly sloping to steep soils on uplands. These soils formed in material weathered from hard caliche. The native grass vegetation was mainly mid grasses.

In a representative profile the surface layer is grayish brown loam about 6 inches thick. The underlying material is light brownish gray, friable light gravelly loam that contains many fragments of hard caliche. Hard caliche is at a depth of 14 inches.

Permeability is moderate, and the available water capacity is very low. Fertility is low. Surface runoff is rapid.

Canlon soils are not suited to cultivation because they are shallow over caliche. They are better suited to native grasses. They are well suited to habitat for openland wildlife. Their limitations for many nonfarm uses are moderate to severe.

Most areas of these soils are used for native grasses.

Representative profile of Canlon loam, in an area of Campus-Canlon complex, 5 to 30 percent slopes, in native grass, about 1,600 feet north and 400 feet east of the southwest corner of sec. 28, T. 1 S., R. 13 W.

A1—0 to 6 inches, grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium and fine, granular structure; slightly hard, friable; many fine roots; few worm casts; strong effervescence; moderately alkaline; clear smooth boundary.

Cca—6 to 14 inches, light brownish gray (10YR 6/2) light gravelly loam, grayish brown (10YR 5/2) when moist; massive; slightly hard, friable; numerous roots; violent effervescence; hard caliche fragments make up about 25 percent of volume and soft masses of calcium carbonate about 25 percent; mildly alkaline; abrupt wavy boundary.

R—14 inches, white (10YR 8/2) hard caliche.

The solum is moderately alkaline or mildly alkaline and has strong to violent effervescence. The depth to bedrock ranges from 10 to 20 inches.

The A1 horizon ranges from grayish brown to light brownish gray when dry and from very dark grayish brown to dark grayish brown when moist. It ranges from loam to sandy loam, with loam as the dominant texture, and is 4 to 6 inches thick. In some places there is an AC horizon about 2 to 4 inches thick. The Cca horizon is light gray to grayish brown light gravelly loam or loam.

Canlon soils were mapped only with Campus soils. Canlon soils are near Campus soils and occupy positions similar to those of Brownell and Heizer soils. Canlon soils are less deep over bedrock than Campus and Brownell soils. They contain fewer coarse fragments than Heizer soils and overlie caliche rather than limestone.

Harney Series

The Harney series consists of deep, well drained, nearly level to sloping soils on loess-covered uplands. These soils formed in deep calcareous silty loess. The native vegetation was mainly short and mid grasses.

In a representative profile (fig. 14) the surface layer is dark grayish brown silt loam about 8 inches thick. The subsoil is about 20 inches thick. The upper 4 inches is dark grayish brown, friable silty clay loam; the middle part is grayish brown and light brownish gray firm heavy silty clay loam 10 inches thick; and the lower 6 inches is pale brown, friable silty clay loam. The underlying material is very pale brown light silty clay loam and silt loam.

Permeability is moderately slow, and the available water capacity is high. Fertility is high. Surface runoff is slow to medium.

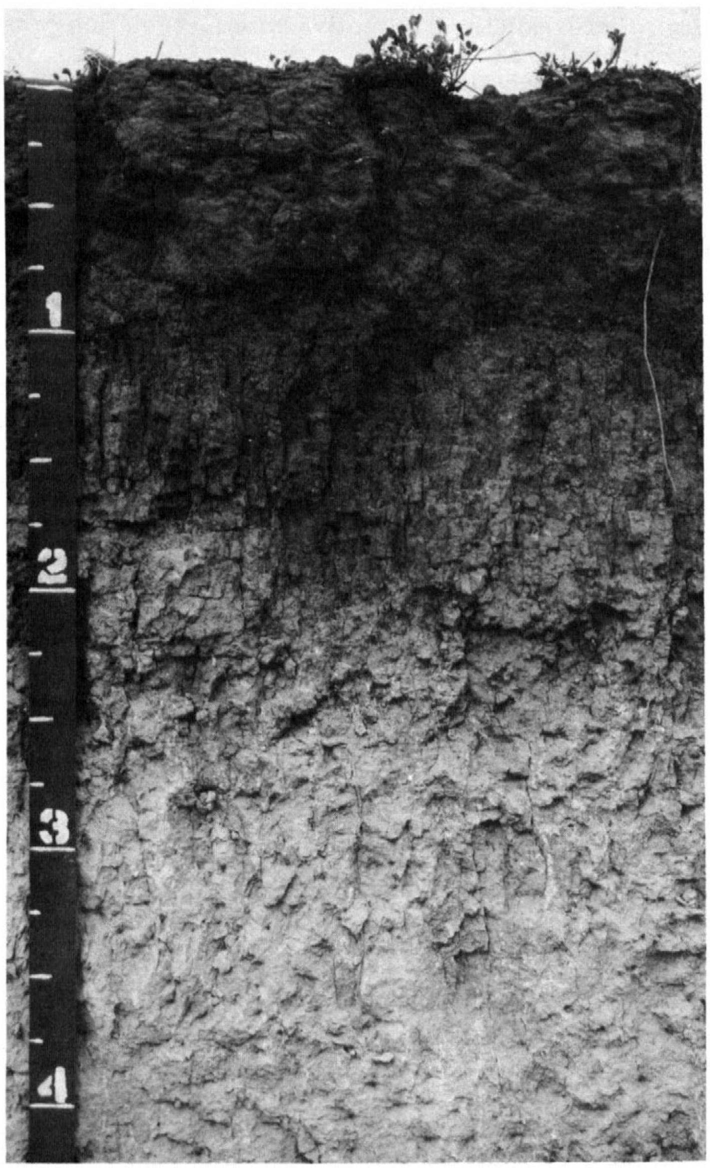

Figure 14.—**Representative profile of Harney silt loam, 1 to 3 percent slopes.**

Harney soils are well suited to farming if erosion is controlled. They are also well suited to habitat for openland wildlife. The limitations for many nonfarm uses are moderate to severe.

Most areas are used for crops, and a few areas of the sloping soils are in native grasses used as range.

Representative profile of Harney silt loam, 1 to 3 percent slopes, in a cultivated field, about 1,200 feet west and 325 feet north of the southeast corner of sec. 33, T. 3 S., R. 12 W.

A1—0 to 8 inches, dark grayish brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium and fine granular structure; slightly hard, friable; many fine roots; numerous worm casts; slightly acid; clear smooth boundary.

B1—8 to 12 inches, dark grayish brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate to strong medium granular structure; hard, friable; many fine roots; numerous clusters of worm casts; slightly acid; clear smooth boundary.

B21t—12 to 16 inches, grayish brown (10YR 5/2) heavy silty clay loam, very dark grayish brown (10YR 3/2) when moist; weak coarse prismatic structure in upper part parting to moderate medium subangular blocky; very hard, firm; thin patchy shiny faces on peds; numerous roots; slightly acid; gradual smooth boundary.

B22t—16 to 22 inches, light brownish gray (10YR 6/2) heavy silty clay loam, dark grayish brown (10YR 4/2) when moist; weak coarse prismatic and moderate fine and medium subangular blocky structure; very hard, firm; continuous shiny faces on peds; numerous roots; neutral; gradual smooth boundary.

B3—22 to 28 inches, pale brown (10YR 6/3) silty clay loam, brown (10YR 4/3) when moist; moderate coarse prismatic and weak fine subangular blocky structure; hard, friable; few roots, few scattered worm casts; neutral; gradual smooth boundary.

C1ca—28 to 42 inches, very pale brown (10YR 7/3) light silty clay loam, brown (10YR 5/3) when moist; weak medium granular structure; slightly hard, friable; few roots; porous; soft masses, films, and threads of calcium carbonate; strong effervescence; moderately alkaline; gradual smooth boundary.

C2—42 to 72 inches, very pale brown (10YR 7/3) silt loam, pale brown (10YR 6/3) when moist; weak fine granular structure changing to massive with depth; slightly hard, friable; porous; yellowish brown (10YR 5/6) stains caused by a few small pipestems or iron concretions; scattered masses of soft calcium carbonate; strong effervescence; moderately alkaline.

The solum is slightly acid to neutral. The depth to free carbonates ranges from 30 inches in nearly level areas to 18 inches on sloping uplands.

The A1 horizon is grayish brown or dark grayish brown and is 4 to 10 inches thick. It ranges from silt loam in the uneroded and native grass areas to light silty clay loam in cultivated areas that have been somewhat eroded. The B21t horizon ranges from heavy silty clay loam to light silty clay. The B22t horizon is light brownish gray or grayish brown heavy silty clay loam or light silty clay. The C horizon is very pale brown to light gray and ranges from light silty clay loam in the upper part to silt loam in the lower part.

Harney soils are near Holdrege, Mento, Nuckolls, and Uly soils. Harney soils have a more clayey B horizon than Holdrege, Nuckolls, or Uly soils. They are leached of free carbonates to a greater depth than Mento soils.

Ha—Harney silt loam, 0 to 1 percent slopes. This is a nearly level soil on the summit of the uplands in areas of 10 to 80 acres. This soil has a profile similar to the one described as representative of the series,

but the surface layer is 8 to 10 inches thick and the depth to free carbonates ranges from 24 to 30 inches.

Included with this soil in mapping, and shown on the map by the symbol for a depressed area, are small depressions in the uplands. Also included are small areas of Holdrege soils and a silt loam soil similar to Harney soil but deeper to free carbonates.

Surface runoff is slow, and the hazard of erosion is slight. Soil blowing is a hazard if conditions are dry and the soil is not protected.

This soil is well suited to farming if moisture is stored and tilth is maintained. It is suited to native grass, wheat, alfalfa, and sorghums. It holds a large amount of water and is well suited to irrigation. Wheat, sorghum, corn, and alfalfa are suitable irrigated crops.

Most of the acreage is cultivated and is used for crops. Winter wheat and grain sorghums are the most commonly grown crops.

The main concerns of management are the lack of soil moisture and soil blowing. Summer fallowing and stubble mulching help conserve moisture and reduce soil blowing. Land leveling helps reduce erosion and insure the uniform penetration and storage of irrigation water. Using underground pipes for conducting water also helps conserve moisture and reduce erosion. The irrigation water should be applied carefully to prevent overirrigation and loss of tail water. Fertilizer should be added to increase yields and to maintain the level of fertility. If available, manure should be added.

This soil has slight to moderate limitations for recreational or urban developments. The main limitation is the low annual rainfall in some years. Capability unit IIc-1, dryfarmed, and I-2, irrigated; Loamy Upland range site; windbreak group 2.

Hb—Harney silt loam, 1 to 3 percent slopes. This is a gently sloping soil in broad, smooth areas that range from medium to large and are continuous on the summit of the uplands. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of Holdrege soils that have slightly convex slopes and are also on the summit of the uplands. Also included are a few small areas of Mento soils, mostly in the southern part of the county, where the loess is thin over chalky shale or soft limestone. In a few small areas erosion has thinned the surface layer. Most of these areas are shown on the soil map by the symbol for a severely eroded spot.

Surface runoff is medium, and the hazard of erosion is moderate. Erosion is a hazard during intensive rains, and soil blowing is a hazard where the soils are dry and bare.

This soil is well suited to cultivated crops and range. Most of it is cultivated and used for crops. Wheat and grain sorghum are the main crops, but alfalfa and silage are also grown. Wheat, corn, sorghums, and alfalfa are grown under irrigation.

The main concerns of management are excess runoff, conserving soil moisture, and erosion. Minimum tillage, stubble mulching, contour farming, terracing, and stripcropping are effective management practices. The cropping system most commonly used consists of sorghum, summer fallow, and wheat. The summer fallow allows moisture to be stored in the soil.

Good management of irrigated areas helps control erosion, maintain fertility, and preserve tilth. Effective management practices are use of crop residue, fertilization, and effective irrigation. Bench leveling and contour and sprinkler irrigation help apply water effectively. Drop structures or underground pipes help control erosion and conserve water.

This soil has moderate to severe limitations for recreational or urban development. Low rainfall limits the use of the soil in some years. Capability unit IIe-3, dryfarmed and irrigated; Loamy Upland range site; windbreak group 2.

Hc—Harney-Mento silt loams, 3 to 7 percent slopes. These are sloping soils on uplands. The complex is about 65 percent Harney silt loam, 20 percent Mento silt loam, 14 percent Holdrege and Wakeen soils, and 1 percent slickspots.

The Harney soil has a profile similar to the one described as representative of the series, but the surface layer is about 2 to 4 inches thinner. The Mento soil has the profile described as representative of the Mento series. The slickspots are in slight depressions that are 20 to 30 inches deep over chalky shale or limestone. They have a thin surface layer of silt loam over layers of light silty clay that has slightly rounded columnar structure. These layers have a high content of carbonates and some sulphates. When farmed, areas tend to "slick" over and are not well suited to cultivated crops.

Runoff is rapid, and the hazard of erosion is severe.

These soils are not well suited to cultivation, because they are susceptible to erosion. Where the soils are cultivated, they are suitable for wheat, grain sorghum, and alfalfa. They are well suited to use as range. Some areas are cultivated, but many areas are in native grasses. Much of the original grass cover has been thinned by overgrazing, but the soils support a moderate to good stand of western wheatgrass and blue grama. A few small pastured areas should be seeded to native grass.

These soils erode if not protected by a growing crop or by crop residue. They need to be protected by native grass or by such practices as terracing, use of waterways, farming on the contour, contour stripcropping, and stubble mulching. These practices help control erosion, conserve moisture, and prevent soil blowing. Summer fallow is needed in some years to store moisture for future crops. Fertilizers such as nitrogen and phosphate are needed to maintain a high level of fertility. If available, manure should be applied.

Unless management maintains fertility, controls erosion, and conserves moisture, these soils can become unproductive and unsuitable for crops. They can be safely cultivated only if intensively managed to control erosion and conserve moisture. Grazing needs to be carefully controlled for high production of forage. Capability unit IVe-1, dryfarmed; Loamy Upland range site; windbreak group 2.

Heizer Series

The Heizer series consists of shallow, somewhat excessively drained, strongly sloping to steep soils over limestone on uplands. These soils formed in material weathered from chalky limestone. The native vegetation was mainly mid and tall grasses.

In a representative profile the surface layer is gray gravelly loam about 8 inches thick. The underlying layer is grayish brown channery loam. Hard chalky limestone is at a depth of 14 inches.

Permeability is moderate, and the available water capacity is very low. Fertility is low. Surface runoff is rapid.

Heizer soils are not suited to crops because they are shallow to bedrock. They are suited to habitat for openland wildlife and are best suited to native grass range. The limitations for many nonfarm uses are moderate to severe.

Most areas of these soils are used for range.

Representative profile of Heizer gravelly loam, in an area of Heizer-Brownell complex, 7 to 30 percent slopes, in native grass, about 2,200 feet south and 200 feet west of the northeast corner of sec. 32, T. 5 S., R. 13 W.

A1—0 to 8 inches, gray (10YR 5/1) gravelly loam, very dark grayish brown (10YR 3/2) when moist; moderate medium granular structure; slightly hard, friable; many fine roots; numerous worm casts; numerous small fragments of limestone gravel; strong effervescence; moderately alkaline; clear smooth boundary.

C—8 to 14 inches, grayish brown (10YR 5/2) channery loam, dark grayish brown (10YR 4/2) when moist; moderate fine granular structure; slightly hard, friable; few fine roots; many fragments of limestone 1 to 6 inches in diameter; violent effervescence; moderately alkaline; abrupt smooth boundary.

R—14 inches, white (10YR 8/2) chalky limestone that has few vertical cracks.

The depth to chalky limestone bedrock ranges from 10 to 20 inches.

The A1 horizon ranges from gray or light gray loam to gravelly loam and is 6 to 8 inches thick. An AC horizon present in some profiles ranges from 2 to 4 inches in thickness.

Heizer soils were mapped only with Brownell soils. Heizer soils are near Brownell and Wakeen soils and occupy positions similar to those of Canlon soils. Heizer soils are more shallow to bedrock than Brownell soils. Heizer soils have coarse fragments and are formed in material weathered from limestone, whereas the Canlon soils are formed in material weathered from hard caliche. Heizer soils are shallower over bedrock than Wakeen soils and contain coarse fragments.

Hd—Heizer-Brownell complex, 7 to 30 percent slopes. These are strongly sloping to steep soils in erosional areas below the loess-capped uplands. The complex is about 60 percent Heizer gravelly loam and 40 percent Brownell gravelly loam.

Included with this unit in mapping are small areas of Armo soils on side slopes below the Heizer soils.

Runoff is rapid, and the hazard of erosion is severe. The shallowness of the root zone is the main limitation.

These soils are not suited to cultivation. They are best suited to native grass range. These soils are mainly in range used for livestock. Much of the original grass cover has been thinned by overgrazing in some areas, but the soils support a good stand of native grasses.

The chief concerns of management are the low to very low available water capacity and controlling erosion. If the native grass is well managed, good yields of forage are obtained.

Grazing must be carefully controlled for high production of forage. Rotation grazing is needed to maintain a good cover of grass, increase the intake of water, and conserve moisture. Capability unit VIIs-1, dryfarmed; Heizer soil in Shallow Limy range site and not placed in a windbreak group; Brownell soils in Limy Upland range site and windbreak group 3.

Holdrege Series

The Holdrege series consists of deep, well drained, gently sloping to strongly sloping soils on loess-capped uplands. These soils formed in calcareous silty loess. The native vegetation was mainly short and mid grasses.

In a representative profile (fig. 15) the surface layer is grayish brown silt loam about 10 inches thick. The subsoil is friable and about 18 inches thick. In the upper 4 inches it is grayish brown light silty clay loam; in the 8 inches below that it is grayish brown silty clay loam; and in the lower 6 inches it is pale brown light silty clay loam. The underlying material is very pale brown silt loam.

Permeability is moderate, and the available water capacity is high. Fertility is medium to high. Surface runoff is medium to rapid.

Holdrege soils are well suited to farming if erosion is controlled, and they are suited to native grasses used as range. They are well suited to habitat for openland wildlife. Their limitations for most nonfarm uses are slight to moderate.

Most areas of the gently sloping soils are used for crops, and areas of the strongly sloping soils are in native grasses.

Representative profile of Holdrege silt loam, 3 to 7 percent slopes, in native grass, about 2,200 feet west and 400 feet south of the northeast corner of sec. 34, T. 1 S., R. 15 W.

A1—0 to 10 inches, grayish brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate fine granular structure; slightly hard, friable; many fine roots; many worm casts; slightly acid; clear smooth boundary.

B1—10 to 14 inches, grayish brown (10YR 5/2) light silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate medium granular structure; hard, friable; numerous roots; few worm casts; slightly acid; gradual smooth boundary.

B2t—14 to 22 inches, grayish brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) when moist; moderate fine subangular blocky and moderate medium granular structure; hard, friable; numerous roots; thin shiny faces on peds; neutral; gradual smooth boundary.

B3—22 to 28 inches, pale brown (10YR 6/3) light silty clay loam, brown (10YR 5/3) when moist; weak

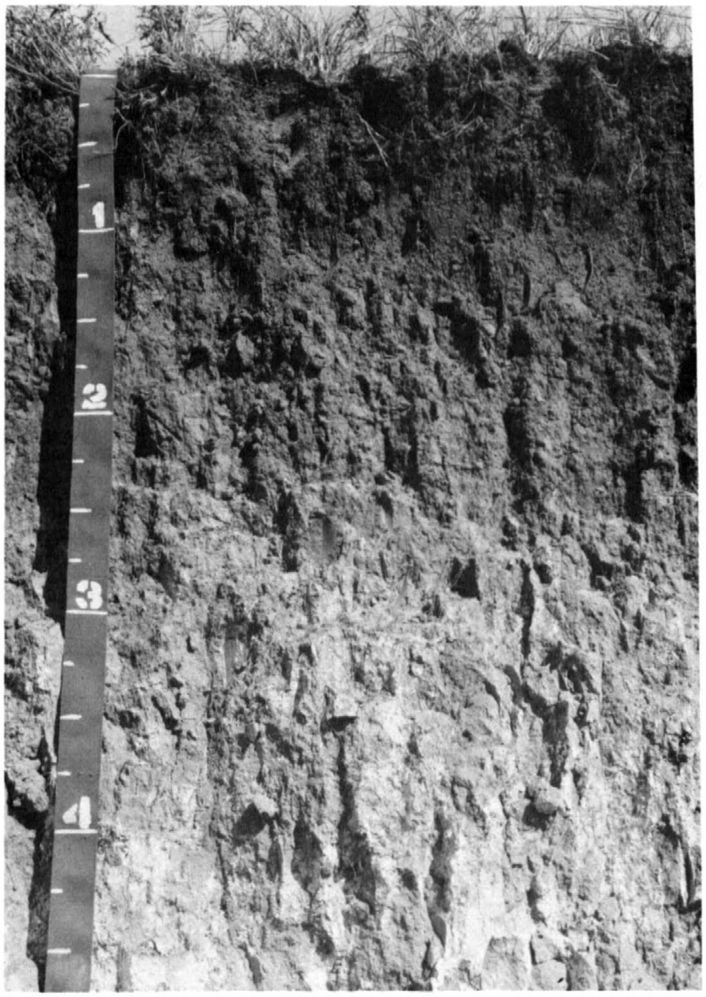

Figure 15.—**Representative profile of Holdrege silt loam, 3 to 7 percent slopes.**

coarse prismatic and weak fine granular structure; hard, friable; few roots; neutral; gradual smooth boundary.

C—28 to 72 inches, very pale brown (10YR 7/3) silt loam, pale brown (10YR 6/3) when moist; weak coarse prismatic structure or massive; slightly hard, friable; porous; few roots; soft films of calcium carbonate coated on cleavage planes; strong effervescence; moderately alkaline.

The solum is slightly acid to neutral. It is 22 to 36 inches thick. The clay content between depths of 10 and 40 inches ranges from 32 to 35 percent.

The A1 horizon is grayish brown to dark grayish brown and is 8 to 10 inches thick. The B1 horizon is 2 to 6 inches thick. The B2t horizon is light gray to dark grayish brown. The C horizon is silt loam to light silty clay loam and ranges from very pale brown to grayish brown.

Holdrege soils are near Harney, Nuckolls, Penden, and Uly soils. They are less clayey than Harney soils. Holdrege soils are leached of free carbonates to a greater depth than Uly and Penden soils. They have a more clayey B horizon than Nuckolls soils and formed in younger gray loess. They are more silty and less calcareous than Penden soils.

He—Holdrege silt loam, 1 to 3 percent slopes. This is a gently sloping soil in broad areas that range from small to large. It has a profile similar to the one described as representative of the series, but the surface layer and subsoil are thicker. The depth to free carbonates ranges from 28 to 40 inches.

Included with this soil in mapping are small areas of Harney and Uly soils. Also included, and shown on the map by the symbol for a severely eroded spot, are a few small areas of an eroded soil that is slightly lighter in color than this mapping unit and has a surface layer of light silty clay loam.

Surface runoff is medium, and the hazard of erosion is slight to medium.

This is a good soil for cultivated crops. It is suitable for wheat, sorghums used for both grain and silage, alfalfa, and sweetclover. Because this soil erodes easily, it is not well suited to irrigation. It is well suited to farming if erosion is controlled and tilth is maintained. It is also suited to native grasses.

Much of the acreage is cultivated, but about one-fourth is still in native grasses.

The main concerns of management are erosion and the lack of soil moisture. When the soil is bare, soil blowing is a hazard. Good management practices include stubble mulching to control soil blowing and to increase the rate of infiltration, contour tillage and terracing to control erosion, and summer fallowing to store moisture. If the soil is used for range, good management includes a proper rate of stocking and rotation grazing.

If the soil is irrigated, irrigation water should be carefully managed and erosion control and water conserving practices should be applied. Contour furrowing and bench leveling help reduce erosion, conserve water, and insure the uniform penetration of moisture. Using underground pipes or gated pipes helps prevent the loss of water by evaporation and deep percolation. If contour ditches are used, care must be taken to use the correct pipe size. Fertilizer needs to be added to maintain the level of fertility.

This soil has slight to moderate limitations for recreational or urban development. Capability unit IIe-1, dryfarmed and irrigated; Loamy Upland range site; windbreak group 2.

Hf—Holdrege silt loam, 3 to 7 percent slopes. This is a sloping soil on loess-covered uplands in medium to large, irregularly shaped areas. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of Harney, Nuckolls, and Uly soils on uplands. Also included, on the floors of upland drainageways, are areas of Roxbury soils, which are subject to flooding. Small areas of severely eroded soils are included and are indicated on the map by the symbol for a severely eroded spot.

Surface runoff is rapid, and the hazard of erosion is moderate. Soil blowing is a hazard where the surface is bare.

This soil is fairly good for cultivated crops. It is suitable for wheat and grain sorghum (fig. 16). It is also suitable for range. About half the acreage is still in native grass and is used for range.

Figure 16.—Harvesting forage sorghum for silage on sloping Holdrege soils.

The main concern of management is reducing erosion. This soil erodes if not protected by a growing crop or by crop residue. It must be protected by vegetation or by such practices as terracing, use of waterways, contour stripcropping, and stubble mulching. These practices help to control erosion, conserve moisture, and prevent soil blowing. Good management is needed to maintain or improve the stand of range plants. Deferred grazing and rotation grazing help produce adequate forage for livestock and leave a protective cover on the soils. Pasture furrowing can also be used to conserve moisture.

This soil has moderate limitations for recreational and urban development. Capability unit IIIe-1, dryfarmed; Loamy Upland range site; windbreak group 2.

Hg—Holdrege silty clay loam, 3 to 7 percent slopes, eroded. This is a sloping soil on loess-capped uplands. It has a profile similar to the one described as representative of the series, but the combined surface layer and subsoil is thinner. Erosion has thinned the surface layer, and as a result much of the organic matter has been lost. Tillage has mixed part of the subsoil with the material in the surface layer. In some areas the surface layer is silt loam.

Included with this soil in mapping are areas of Uly soils, which have a surface layer of silt loam.

Surface runoff is rapid, and the hazard of erosion is severe. Soil blowing is a serious hazard where the soil does not have a rough surface or is not adequately protected by vegetation or crop residue.

This soil is better suited to wheat than to other crops. It is also suited to sorghum, but sorghum is likely to be affected by chlorosis. Some areas of this soil that are near range are better suited to native grass range than to crops. Nearly all of the acreage is or has been cultivated. Most of it is used for crops. This soil is productive in years when rainfall is average or above average, but fertilizers are needed to maintain fertility.

The main concern of management is controlling erosion. This soil can be safely cultivated only if erosion is controlled. Terracing and using waterway outlets, contour farming, stubble mulching, and summer fallowing help to control erosion, conserve moisture, prevent soil blowing, and increase moisture storage. When properly managed, this soil produces good yields of grasses for livestock.

This soil has slight to moderate limitations for recreational or urban developments. Capability unit IIIe-3, dryfarmed; Loamy Upland range site; windbreak group 2.

Hord Series

The Hord series consists of deep, well drained, nearly level soils on benches or terraces along streams. These soils formed in silty alluvium. The native vegetation was mainly mid and tall grasses.

In a representative profile the surface layer is gray silt loam about 15 inches thick. The subsoil is grayish brown, friable silt loam about 27 inches thick. The underlying material is light brownish gray heavy silt loam.

Permeability is moderate, and the available water capacity is high. Fertility is high. Surface runoff is slow.

Hord soils are well suited to cultivation. They are also well suited to habitat for openland wildlife and to range. The limitations for nonfarm uses are slight.

Most areas of these soils are used for crops.

Representative profile of Hord silt loam, in a cultivated field, about 1,200 feet east and 750 feet north of the southwest corner of sec. 7, T. 2 S., R. 15 W.

A1—0 to 15 inches, gray (10YR 5/1) silt loam, very dark gray (10YR 3/1) when moist; moderate fine and medium granular structure; slightly hard, friable; many roots; many worm casts; slightly acid; gradual smooth boundary.

B2—15 to 32 inches, grayish brown (10YR 5/2) heavy silt loam, very dark grayish brown (10YR 3/2) when moist; moderate medium granular structure; hard, friable; many roots; few worm casts; neutral; gradual smooth boundary.

B3—32 to 42 inches, grayish brown (10YR 5/2) heavy silt loam, dark grayish brown (10YR 4/2) when moist; moderate medium granular structure; hard, friable; numerous fine roots; many small masses of soft calcium carbonate; strong effervescence; mildly alkaline; gradual smooth boundary.

C—42 to 72 inches, light brownish gray (10YR 6/2) heavy silt loam, dark grayish brown (10YR 4/2) when moist; weak medium granular structure; hard, friable; few fine roots; few soft masses of calcium carbonate; strong effervescence; moderately alkaline.

The solum is slightly acid to mildly alkaline. The depth to calcareous material is 20 to 42 inches.

The A1 horizon is silt loam and is 10 to 16 inches thick. The B2 horizon is silt loam to light silty clay loam and 12 to 18 inches thick. The B3 horizon ranges from silt loam to light silty clay loam, has masses of soft calcium carbonate, and is 10 to 20 inches thick. The C horizon is light silty clay loam to silt loam.

Hord soils are near McCook and Roxbury soils and they are leached of carbonates to a greater depth than either of these soils.

Hh—Hord silt loam. This is a nearly level soil in broad, smooth, small to large areas on benches along the streams. Slope is 0 to 1 percent. Included in mapping are small areas of Roxbury and McCook soils.

Surface runoff is slow, and the hazard of erosion is slight. Soil blowing is also a hazard where the soil is dry and unprotected.

This soil is the best in the county for intensive cropping. It is fertile and is important for farming. Some areas make up entire fields. Most areas of this soil are cultivated to common crops, but small areas that are a part of large areas of rangeland are still in range. Wheat, alfalfa, corn, and grain and forage sorghums are grown.

The main concern of management is the lack of soil moisture that limits crop production in some years. Crop residue management is needed to control soil blowing and conserve moisture. In some years summer fallowing is needed to store moisture.

This soil is irrigated in fields where it is below the Kirwin Ditch or where wells have been established for irrigation water. Land leveling, use of underground pipes, and careful management of irrigation water are needed to control erosion and evaporation on irrigated lands. These practices also insure uniform penetration of water.

Fertilizer needs to be added to maintain the level of fertility. Proper tillage and management are needed to maintain good tilth. These soils produce large amounts of forage when properly managed.

This soil has slight limitations for recreational and urban development. Capability unit I-1, dryfarmed and irrigated; Loamy Terrace range site; windbreak group 1.

Inavale Series

The Inavale series consists of deep, somewhat excessively drained, nearly level to gently sloping soils on sandy lowlands. These soils formed in sandy alluvium. The native vegetation was mid and tall grasses.

In a representative profile the surface layer is grayish brown loamy fine sand about 9 inches thick. The next layer is light brownish gray soft loamy fine sand about 9 inches thick. The underlying material is very pale brown fine sand that has a few pebbles.

Permeability is rapid, and the available water capacity is low. Fertility is low. Surface runoff is slow.

Inavale soils are not well suited to cultivation because there is a hazard of soil blowing, but they are well suited to native grasses used as range. They are suited to habitat for openland wildlife. The limitations for many nonfarm uses are severe.

Representative profile of Inavale loamy fine sand, in an area of Inavale-Munjor complex, about 2,000 feet north and 100 feet west of the southeast corner of sec. 20, T. 5 S., R. 13 W.

Ap—0 to 9 inches, grayish brown (10YR 5/2) loamy fine sand, dark grayish brown (10YR 4/2) when moist; weak fine granular structure; loose, soft; numerous fine roots; slight effervescence; mildly alkaline; clear smooth boundary.

AC—9 to 18 inches, light brownish gray (10YR 6/2) loamy fine sand, grayish brown (10YR 5/2) when moist; weak fine granular structure; loose, soft; few roots; slight effervescence; mildly alkaline; abrupt smooth boundary.

C—18 to 72 inches, very pale brown (10YR 7/3) fine sand, pale brown (10YR 6/3) when moist; single grained; loose; thin strata of finer-textured sediment; few fine roots; slight effervescence; mildly alkaline.

The depth to fine sand ranges from 6 to 24 inches. Free carbonates are throughout the profile.

The Ap horizon ranges from loamy fine sand in smoother areas to fine sand in the overblown areas and is 5 to 12 inches thick. The C horizon is loamy sand to fine sand in the upper part.

Inavale soils were mapped only with Munjor soils. Inavale soils are near Munjor soils but are more sandy.

Im—Inavale-Munjor complex. These are nearly level to gently sloping soils on flood plains. Slope is 0 to 2 percent. The complex is about 60 percent Inavale soils and about 40 percent Munjor soils.

Inavale soils have a profile similar to the one described as representative of the series, but the surface layer is mainly loamy fine sand in smoother areas and fine sand in undulating areas. The fine sand wind hummocks are shown by the symbol for a fine sand spot. These sandy areas are best suited to native grasses.

Soil blowing, erosion in places, and inadequate soil moisture are hazards.

These soils are suited to cultivated crops if protective measures are used. Most areas are in native grass and many have been seeded to native grasses. Some areas are used for crops, and a small acreage is irrigated. Wheat and sorghum are the main crops. Forage crops are also grown. Areas in native grasses produce large amounts of forage.

The main concerns of management are controlling soil blowing, conserving moisture, and maintaining fertility. Among the effective management practices are minimum tillage, use of crop residue, and fertilization. Bench leveling and sprinkler irrigation help to make irrigation effective. Underground pipes or gated pipes reduce loss of water.

Proper stocking rates and rotational grazing are needed to manage range for high yields.

These soils have moderate to severe limitations for recreational and urban developments. Capability unit IVe-4, dryfarmed; Inavale soils in Sands range site and not in a windbreak group; Munjor soils in Sandy range site and windbreak group 1.

McCook Series

The McCook series consists of deep, well drained, nearly level soils on benches and lowlands along streams. These soils formed in calcareous coarse silty alluvium. The native vegetation was mid and tall grasses.

In a representative profile the surface layer is grayish brown coarse silt loam about 10 inches thick. The next layer is light brownish gray, friable coarse silt loam about 8 inches thick. The underlying material is light gray coarse silt loam.

Permeability is moderate, and the available water capacity is high. Fertility is high. Surface runoff is slow.

McCook soils are well suited to cultivated crops if soil blowing is controlled, and they are suited to native grasses used as range. They are well suited to habitat for openland wildlife. Their limitations for nonfarm uses are slight to moderate. The soil characteristics are favorable for irrigation.

Representative profile of McCook silt loam, in a cultivated field, about 500 feet west and 300 feet south of the northeast corner of sec. 2, T. 5 S., R. 14 W.

A1—0 to 10 inches, grayish brown (10YR 5/2) coarse silt loam, very dark grayish brown (10YR 3/2) when moist; moderate fine granular structure; slightly hard, friable; many fine and medium roots; many worm casts; slight effervescence; mildly alkaline; gradual smooth boundary.

AC—10 to 18 inches, light brownish gray (10YR 6/2) coarse silt loam, dark grayish brown (10YR 4/2) when moist; weak fine granular structure; slightly hard, friable; numerous roots; strong effervescence; mildly alkaline; gradual smooth boundary.

C1—18 to 40 inches, light gray (10YR 7/2) coarse silt loam, grayish brown (19YR 5/2) when moist; weak granular structure; slightly hard, friable; porous; numerous roots; strong effervescence; moderately alkaline; gradual smooth boundary.

C2—40 to 72 inches, light gray (10YR 7/2) coarse silt loam, grayish brown (10YR 5/2) when moist; massive; porous, slightly hard, friable; few roots; firm and small soft masses of calcium carbonate on peds; violent effervescence; moderately alkaline.

The solum is mildly alkaline to moderately alkaline. The A1 horizon is dark grayish brown to grayish brown loam to coarse silt loam and is 8 to 16 inches thick. The AC horizon is 8 to 20 inches thick. The lower part of the C horizon is more stratified and ranges from coarse silt loam to very fine sandy loam. In places on the benches, a buried A horizon is below a depth of 40 inches.

McCook soils were mapped with Munjor soils. McCook soils are near Munjor, Hord, and Roxbury soils. McCook soils are more loamy than Munjor soils. McCook soils contain more carbonates throughout the profile than Hord soils. McCook soils are dark to a lesser depth than Roxbury soils. They are less clayey than Hord and Roxbury soils.

Ma—McCook silt loam. This soil is in broad, smooth, medium to large areas on benches. It has the profile described as representative of the series. Slope is 0 to 1 percent.

Included with this soil in mapping are small areas of Hord and Roxbury soils on the nearly level benches.

Surface runoff is slow, and the hazard of erosion is slight. Soil blowing is a hazard where the soils are bare because the content of carbonates is high and the surface layer is coarse silt loam.

Wheat, corn, alfalfa, grain and forage sorghums, and other small grains are grown on these soils under normal conditions and under irrigation. In some areas the sorghum is likely to be affected by chlorosis.

Nearly all of the acreage is cultivated. Small areas in native grass are used as range when they are a part of range areas. Some cultivated areas are irrigated.

The main concerns of management are the high percentage of calcium carbonate in the soil and the low annual rainfall that tends to limit production of crops. Management of residue is needed to control soil blowing and conserve moisture. Land leveling, use of underground pipes, and careful management of irrigation water are needed to control erosion and evaporation in irrigated areas and insure uniform penetration of water. Fertilizer should be applied to maintain fertility.

This soil has slight limitations for recreational or urban developments. Capability unit I-1, dryfarmed and irrigated; Loamy Terrace range site; windbreak group 1.

Mm—McCook-Munjor complex. These are nearly level and contiguous soils in large areas on the lower parts of flood plains. Slope is 0 to 1 percent. The com-

plex is about 60 percent McCook soils and 40 percent Munjor soils.

McCook soils have a profile similar to the one described as representative of the series, but the surface layer ranges from loam to coarse silt loam. Below a depth of 40 inches these soils are stratified in places with coarse silty and sandy alluvium. They are in slightly higher areas of the complex.

Munjor soils have a profile similar to the one described as representative of the Munjor series, but the surface layer is fine sandy loam and loam. Munjor loam is stratified with loams and fine sands in most places below a depth of 40 inches. Munjor soils are occasionally flooded.

Included with this unit in mapping are small areas of Roxbury silt loam, frequently flooded, on the nearly level flood plains; and small areas of Alluvial land, loamy, along the streams.

Runoff is slow, and erosion is not a hazard. Excess water from overflow tends to limit production.

These soils are best suited to corn, grain, and forage sorghums. Wheat and alfalfa are grown, but they can be damaged by flooding. Nearly all the areas are used for cultivated crops, but small areas are still in native grass. Where these soils are used for range, yields of forage are high.

The chief concern of management is the flooding of growing crops in some years. Proper tillage, flood control, and crop residue management are needed to conserve soil moisture and improve tilth. These soils are fertile, but fertilizer should be applied to maintain fertility and high yields. Summer fallow is practiced in some years to change the kind of crops grown in the rotation. Capability unit IIw-1, dryfarmed and irrigated; Loamy Lowland range site; windbreak group 1.

Mento Series

The Mento series consists of deep, well drained, sloping soils on loess-covered uplands. These soils formed in loess. The native vegetation was mainly mid and short grasses.

In a representative profile the surface layer is grayish brown silt loam about 8 inches thick. The subsoil is 24 inches thick. In the upper 10 inches it is dark grayish brown very firm heavy silty clay loam; in the lower 14 inches it is pale brown, friable light silty clay loam. The underlying material is pale brown light silty clay loam. Chalky limestone is at a depth of 64 inches.

Permeability is slow, and the available water capacity is high. Fertility is medium to high. Surface runoff is moderately rapid.

Mento soils are suited to cultivation if erosion is controlled, and they are well suited to native grasses used as range. They are well suited to habitat for openland wildlife. The limitations for most nonfarm uses are moderate to severe.

These soils are used for crops and native grasses.

Representative profile of Mento silt loam, in an area of Harney-Mento silt loams, 3 to 7 percent slopes, in native vegetation, about 1,200 feet south and 600 feet east of the northwest corner of sec. 17, T. 14 S., R. 11 W.

A1—0 to 8 inches, grayish brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate fine granular structure; slightly hard, friable; neutral; abrupt smooth boundary.

B2t—8 to 18 inches, dark grayish brown (10YR 4/2) heavy silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate fine columnar structure breaking to moderate medium subangular blocky; very hard, very firm; few fine roots; mildly alkaline; gradual smooth boundary.

B3ca—18 to 32 inches, pale brown (10YR 6/3) light silty clay loam, dark brown (10YR 4/3) when moist; moderate fine subangular blocky structure; hard friable; few roots; common soft calcium carbonate accumulations; strong effervescence; moderately alkaline; gradual smooth boundary.

Cca—32 to 64 inches, pale brown (10YR 6/3) light silty clay loam, brown (10YR 5/3) when moist; weak fine granular structure; hard, friable; violent effervescence; moderately alkaline; clear wavy boundary.

IIR—64 to 72 inches, white (10YR 8/2) soft chalky limestone.

The solum is neutral to moderately alkaline. The depth to free carbonates ranges from 10 to 20 inches. The depth to soft chalky limestone ranges from 40 to 70 inches.

The A horizon ranges from grayish brown to dark brown and is 5 to 10 inches thick. It ranges from silt loam in uneroded and native grass areas to silty clay loam in eroded areas. The B2t horizon is light silty clay or heavy silty clay loam and is 8 to 10 inches thick. The B3 horizon ranges from clay loam to silty clay loam. The C horizon ranges from light clay loam to heavy silty clay loam and is calcareous.

Mento soils were mapped only with Harney soils. Mento soils are near Harney and Wakeen soils. Mento soils are leached of free carbonates to a lesser depth than Harney soils. Mento soils are more clayey and are leached of free carbonates to a greater depth than Wakeen soils.

Munjor Series

The Munjor series consists of deep, well drained, nearly level to gently sloping soils on flood plains of the North Fork of the Solomon River. These soils formed in moderately sandy alluvium. The native vegetation was mainly tall grasses.

In a representative profile the surface layer is grayish brown fine sandy loam about 6 inches thick. The underlying material is light brownish gray light fine sandy loam about 32 inches thick over very pale brown fine sand.

Permeability is moderately rapid, and the available water capacity is moderate. Fertility is medium. Surface runoff is slow.

Munjor soils are suited to cultivated crops if soil blowing is controlled. They are well suited to habitat for openland wildlife and are also well suited to native grasses used as range. The limitations for many nonfarm uses are moderate.

These soils are used for crops and range.

Representative profile of Munjor fine sandy loam, in an area of Inavale-Munjor complex, in a field seeded to native grass, about 2,400 feet north and 200 feet west of the southeast corner of sec. 20, T. 5 S., R. 13 W.

A1—0 to 6 inches, grayish brown (10YR 5/2) fine sandy loam, dark grayish brown (10YR 4/2) when moist;

weak fine granular structure; slightly hard, very friable; few roots; slight effervescence; mildly alkaline; gradual smooth boundary.

C—6 to 38 inches, light brownish gray (10YR 6/2) light fine sandy loam, grayish brown (10YR 5/2) when moist; weak medium granular structure in the upper part ranging to massive in the lower part; slightly hard, very friable; few roots; strong effervescence; moderately alkaline; abrupt, smooth boundary.

IIC—38 to 72 inches, very pale brown (10YR 7/3) fine sand, pale brown (10YR 6/3) when moist; single grained; loose, soft; strong effervescence; moderately alkaline.

The solum is mildly alkaline to moderately alkaline. The depth to fine sand or sandy sediments ranges from 28 to 42 inches. Small rounded pebbles are throughout the profile.

The A1 horizon is grayish brown to light brownish gray and 4 to 12 inches thick. In places it is very dark grayish brown, moist, but it is less than 7 inches thick. It is fine sandy loam to heavy loam in most places, but is loamy fine sand where wind action has winnowed 3 to 4 inches of the surface layer. The C horizon is fine sandy loam.

Munjor soils were mapped only with Inavale and McCook soils, which they are near. They are less sandy than Inavale soils and are more sandy than McCook soils.

New Cambria Series

The New Cambria series consists of deep, moderately well drained, nearly level soils on terraces along streams. These soils formed in clayey alluvium. The native vegetation was mid and tall grasses.

In a representative profile the surface layer is gray silty clay about 10 inches thick. The subsoil is gray, very firm silty clay about 26 inches thick. The underlying material is light brownish gray silty clay.

Permeability is slow, and the available water capacity is moderate. The soil is droughty at times because of high content of clay. Fertility is high. Surface runoff is slow to medium.

New Cambria soils are suited to farming, but water conserving practices are needed to increase storage of water. They are suited to habitat for openland wildlife and are well suited to native grass used as range. The limitations for many nonfarm uses are severe.

Most areas are used for crops, but some small areas are in native grasses.

Representative profile of New Cambria silty clay, in native grass, about 800 feet south and 100 feet west of the northeast corner of sec. 23, T. 5 S., R. 11 W.

A1—0 to 10 inches, gray (10YR 5/1) light silty clay, very dark gray (10YR 3/1) when moist; moderate medium granular structure; very hard, very firm; many fine roots; slight effervescence; mildly alkaline; abrupt smooth boundary.

B21—10 to 24 inches, gray (10YR 5/1) silty clay, very dark gray (10YR 3/1) when moist; moderate medium granular structure; very hard, very firm; many fine roots; slight effervescence; moderately alkaline; abrupt smooth boundary.

B22—24 to 36 inches, gray (10YR 5/1) silty clay, dark gray (10YR 4/1) when moist; weak medium subangular blocky structure; extremely hard, very firm; numerous fine roots; few small hard calcium carbonate crystals, scattered films and threads of calcium carbonate; slight effervescence; moderately alkaline; diffuse smooth boundary.

C—36 to 72 inches, light brownish gray (10YR 6/2) silty clay, grayish brown (10YR 5/2) when moist; weak medium subangular blocky structure to massive; very hard, firm; few fine roots; films and threads of calcium carbonate, many small soft accumulations of calcium carbonate concretions; strong effervescence; moderately alkaline.

The solum is mildly alkaline to moderately alkaline.

The A1 horizon is heavy silty clay loam to silty clay and is 9 to 12 inches thick. The B21 horizon is gray to light gray and is 10 to 20 inches thick. The C horizon ranges from light gray to grayish brown silty clay loam to silty clay.

New Cambria soils are near Roxbury and Bogue soils. New Cambria soils are more clayey than Roxbury soils. New Cambria soils are deeper than Bogue soils and are less clayey.

Nc—New Cambria silty clay. This is a nearly level soil in large, smooth areas on terraces. Slope is 0 to 2 percent.

Included with this soil in mapping are small areas of Roxbury soils. Also included, and near the uplands, is a clayey soil similar to Bogue soil.

This soil is suited to cultivation if tilth is maintained. Nearly all of the acreage is used for cultivation. Most of it is used for crops. Some areas are irrigated. Wheat, alfalfa, and grain and forage sorghums are the principal crops.

The clayey texture of the soil limits production because it reduces the intake of moisture. In the cropping system, crops are alternated with summer fallow to increase the moisture-storing capacity of the soil.

In irrigated areas satisfactory yields are obtained only if the quality of irrigation water is good and water and fertilizer are applied carefully. Suitable native grasses produce abundant forage under good management.

This soil has severe limitations for recreational or urban developments. Capability unit IIs-1, dryfarmed and irrigated; Clay Terrace range site; windbreak group 1.

Nuckolls Series

The Nuckolls series consists of deep, well drained, sloping to strongly sloping soils on loess-covered uplands. These soils formed in silty loess. The native vegetation was mainly short and mid grasses.

In a representative profile the surface layer is dark grayish brown silt loam about 10 inches thick. The subsoil is pinkish gray and light brown, friable light silty clay loam and heavy silt loam about 20 inches thick. The underlying material is light brown silt loam.

Permeability is moderate, and the available water capacity is high. Fertility is high.

Nuckolls soils are suited to cultivation if erosion is controlled. They are also suited to habitat for openland wildlife and are well suited to native grass range. The limitations to many nonfarm uses are moderate to severe.

These soils are used for crops and range.

Representative profile of Nuckolls silt loam in an area of Nuckolls-Holdrege silt loams, 3 to 7 percent slopes, in native grass, about 2,300 feet south and 300 feet west of the northeast corner of sec. 8, T. 1 S., R. 12 W.

A1—0 to 10 inches, dark grayish brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) when moist; moderate fine granular structure; slightly hard, friable; many fine roots; occasional worm casts; slightly acid; clear smooth boundary.

B2—10 to 20 inches, pinkish gray (7.5YR 6/2) light silty clay loam, brown (7.5YR 5/2) when moist; moderate fine to medium subangular blocky structure; very hard, friable; few roots; neutral; gradual smooth boundary.

B3—20 to 30 inches, light brown (75.YR 6/4) heavy silt loam, brown (7.5YR 5/4) when moist; weak medium subangular blocky structure; hard, friable; few roots; neutral; gradual smooth boundary.

C—30 to 72 inches, light brown (7.5YR 6/4) heavy silt loam, brown (7.5YR 5/4) when moist; weak granular structure; slightly hard, friable; common small concretions of calcium carbonate; slight effervescence; mildly alkaline.

The solum is slightly acid to neutral. Depth to free carbonates is 24 to 44 inches.

The A1 horizon ranges from grayish brown to dark grayish brown silt loam to light silty clay loam and is 7 to 12 inches thick. The B2 horizon is light brown to brown heavy silt loam or silty clay loam. The B3 and C1 horizons are light brown to brown.

Nuckolls soils are near Harney, Holdrege, and Uly soils. Nuckolls soils are less clayey than Harney soils. They have a less clayey B horizon than Holdrege soils and formed in older, browner loess. They differ from Uly soils in being formed in browner loess.

Nd—Nuckolls silt loam, 7 to 12 percent slopes. This is a strongly sloping, loess-covered soil on uplands.

Included with this soil in mapping are small areas of Holdrege and Uly soils on the uplands. Also included are small areas of a soil that is similar to Nuckolls soils but more clayey in the subsoil. In the narrow drainageways are Roxbury soils and soils that are similar to Roxbury soil but leached of carbonates to a greater depth. Areas of eroded soils are included and shown on the map by the symbol for a severely eroded spot. Sandy outcrops on uplands are shown on the map by a symbol for a sand spot.

Runoff is rapid, and the hazard of erosion is severe.

This soil is well suited to native grasses used as range. Cultivated crops can be grown if intensive management is used. Where cultivated, the soil is suitable for wheat, sorghums, alfalfa, and forage crops.

The main concern of management is controlling erosion. This soil is subject to erosion and soil blowing if it is not protected by a growing crop or by crop residue. Protecting the soil with vegetation or using such practices as terracing, contour stripcropping, and stubble mulching helps control erosion, conserve moisture and prevent soil blowing. Summer fallowing is needed in some years to store moisture for future crops. Fertilizers should be applied to maintain fertility. When this soil is cultivated, growing suitable crops in a flexible cropping system and keeping tillage to a minimum are good practices.

When the soil is in native grasses, good range management is needed to maintain or improve the stand of range plants. Deferred grazing and rotation grazing are needed to produce adequate forage for livestock and also leave a protective cover on the soil. This soil has good sites for constructing dams to provide water for livestock.

This soil has moderate limitations for recreational or urban developments. Capability unit IVe-3, dryfarmed; Loamy Upland range site; windbreak group 2.

Nh—Nuckolls-Holdrege silt loams, 3 to 7 percent slopes. These are sloping soils on the sides and crests of uplands. The complex is about 60 percent Nuckolls silt loam, 30 percent Holdrege silt loam, and 10 percent Uly silt loam. The Uly silt loam is slightly lighter colored than the Holdrege silt loam.

In some of the more eroded areas, shown on the map by the symbol for a severely eroded spot, limy subsoil material is exposed at the surface. In some areas, tillage has mixed the subsoil material with the remaining original surface layer. Small areas of sandy sediment are shown on the map by a symbol for a sand spot.

Runoff is moderately rapid, and the hazard of erosion is severe. Soil blowing is also a hazard.

These soils are suited to cultivation. They are suitable for wheat and grain sorghum. Most of the acreage is cultivated, but some is in native grass range.

The main concern of management is erosion. These soils erode and blow if not protected by a growing crop or by crop residue. They need to be protected by vegetation or by such practices as terracing, farming on the contour, contour stripcropping, and stubble mulching. These practices help control erosion, conserve moisture, and prevent soil blowing. Summer fallowing is needed to store moisture for future crops in most years. Fertilizers should be applied to maintain fertility. Careful management of range is needed to maintain good yields of forage.

These soils have slight to moderate limitations for recreational or urban developments. Capability unit IIIe-1, dryfarmed; Loamy Upland range site; windbreak group 2.

Penden Series

The Penden series consists of deep, well drained, sloping soils on uplands. These soils formed in loamy calcareous sediments. The native vegetation was mainly mid and short grasses.

In a representative profile the surface layer is grayish brown loam about 10 inches thick. The subsoil is grayish brown, friable clay loam about 10 inches thick. The underlying material is very pale brown clay loam.

Permeability is moderate, and the available water capacity is high. Fertility is medium to high. Surface runoff is moderately rapid.

Penden soils are suited to cultivation if erosion is controlled. They are well suited to habitat for openland wildlife and are also well suited to native grasses used as range. The limitations for many nonfarm uses are moderate to severe.

Most areas of these soils are used for range, but some areas are cultivated.

Representative profile of Penden loam, 3 to 7 percent slopes, in native grass, 2,200 feet west and 400 feet north of the southeast corner of sec. 9, T. 1 S., R. 15 W.

A1—0 to 10 inches, grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) when moist; moderate medium granular structure; slightly hard, friable; abundant fine roots; many worm casts; slight effervescence; mildly alkaline; gradual smooth boundary.

B2—10 to 20 inches, grayish brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) when moist; weak medium granular structure; hard, friable; many roots; many worm casts; porous; few small quartz grains; few small concretions of calcium carbonate; strong effervescence; mildly alkaline; gradual smooth boundary.

C1ca—20 to 34 inches, very pale brown (10YR 8/3) clay loam, very pale brown (10YR 7/3) when moist; weak medium granular structure; very hard, firm; few roots; few concretions of calcium carbonate; violent effervescence; moderately alkaline; gradual smooth boundary.

C2—34 to 72 inches, very pale brown (10YR 7/3) light clay loam, pale brown (10YR 6/3) when moist; massive; hard, friable; few roots; few small concretions of calcium carbonate; few quartz sand grains; porous; strong effervescence; mildly alkaline.

The solum is mildly alkaline to moderately alkaline. The depth to the C1ca horizon, which has a calcium carbonate content of 15 to 25 percent, is less than 30 inches.

The A1 horizon is dark grayish brown to brown loam or coarse silt loam and is 7 to 12 inches thick. The B2 horizon is grayish brown or brown and is 10 to 18 inches thick.

Penden soils are near Armo, Campus, Holdrege, and Uly soils. Penden soils have a more distinct Cca horizon than Armo soils. They have less calcium carbonate than Campus soils. Penden soils have free carbonates throughout, while Holdrege soils are leached in the upper part of the solum. Penden soils are more sandy and less silty than Holdrege or Uly soils.

Pe—Penden loam, 3 to 7 percent slopes. This is a sloping soil on narrow ridgetops and knolls. Areas are generally long and narrow and range from 10 to 80 acres. The surface layer is slightly thinner in cultivated areas than in areas of native grass.

Included with this soil in mapping are small areas of Uly silt loam. Also included, and shown on the map by the symbol for a severely eroded spot, are severely eroded areas that have a thinner and lighter colored surface layer. Small sandy areas are shown on the may by a symbol for a sand spot.

Surface runoff is rapid, and the hazard of erosion is severe. Soil blowing is also a hazard.

If well managed, this soil is suited to all commonly grown crops. It is used for native range and cultivated crops. Sorghum is the principal crop, but wheat is also grown. Most areas are in native grasses and are used as range.

The main concern of management is erosion. Management practices that help control erosion and conserve moisture include stubble mulching, minimum tillage, terracing, contour farming, and contour stripcropping. Fertilizers should be added to maintain fertility. Fertilizers help provide an adequate cover of vegetation and thus help control erosion. Grazing of crop residue decreases the amount of protective cover needed for controlling erosion. Proper grazing intensity, deferred grazing and rotational grazing help conserve moisture and maintain desirable grasses.

Unless management maintains fertility, controls erosion, and conserves moisture, these soils become eroded, unproductive, and no longer suitable for crops. They may be safely used for cultivated crops if intensive management is used to protect and conserve moisture.

This soil has moderate limitations for recreational or urban developments. Capability unit IIIe-4, dryfarmed; Limy Upland range site; windbreak group 3.

Roxbury Series

The Roxbury series consists of deep, well drained, nearly level to gently sloping soils on terraces and lowlands along major streams. These soils formed in alluvium. The native vegetation was mainly mid and tall grasses.

In a representative profile the surface layer is gray and dark gray silt loam about 30 inches thick. The subsoil is grayish brown, friable light silty clay loam about 20 inches thick. The underlying material is very pale brown heavy silt loam.

Permeability is moderate, and the available water capacity is high. Fertility is high. Surface runoff is slow.

Roxbury soils are well suited to cultivated crops. They are suited to habitat for openland wildlife and are suited to native grasses used as range. The limitations to many nonfarm uses are slight.

Most areas are used for crops and some are irrigated from the Kirwin Ditch.

Representative profile of Roxbury silt loam, in a cultivated field under irrigation, about 100 feet east and 100 feet south of the northwest corner of sec. 31, T. 5 S. R. 12 W.

A1—0 to 24 inches, gray (10YR 5/1) silt loam, very dark gray (10YR 3/1) when moist; moderate fine granular structure; slightly hard, very friable; many roots; many worm casts; slight effervescence; mildly alkaline; gradual smooth boundary.

A3—24 to 30 inches, dark gray (10YR 4/1) heavy silt loam, very dark gray (10YR 3/1) when moist; strong fine granular structure; slightly hard, friable; numerous roots; many worm casts; soft films of calcium carbonate; strong effervescence; mildly alkaline; clear smooth boundary.

B2—30 to 50 inches, grayish brown (10YR 5/2) light silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate medium granular structure; slightly hard, friable; few roots; few worm casts; porous; moderate effervescence; moderately alkaline; gradual smooth boundary.

C—50 to 72 inches, very pale brown (10YR 7/3) heavy silt loam, brown (10YR 5/3) when moist; weak fine granular structure; hard, friable; moderate effervescence; moderately alkaline.

The solum is mildly alkaline to moderately alkaline. The depth to free carbonates is less than 15 inches.

The A1 horizon is grayish brown to dark gray and is 15 to 28 inches thick. The A3 horizon ranges from silt loam to light silty clay loam and is 2 to 6 inches thick. The B2 horizon ranges from silt loam to light silty clay loam and is 10 to 30 inches thick. The C horizon ranges from light gray to very pale brown.

Roxbury soils are near Armo, Hord, McCook, and New Cambria soils. Roxbury soils formed in more silty alluvium and are dark to a greater depth than Armo soils. They are not leached to as great a depth as Hord soils. Roxbury soils are more clayey than McCook soils and less clayey than New Cambria soils.

Ro—Roxbury silt loam. This is a nearly level soil in broad, medium to large areas along streams on benches. These areas make up whole fields in places.

This soil is fertile and is important for farming. It has the profile described as representative of the series. Slope is 0 to 1 percent. Included in mapping are small areas of Hord soils in slightly higher positions.

Surface runoff is slow, and the hazard of erosion is slight. Soil blowing is a hazard where the soil is dry and unprotected.

Most areas of this soil are used for crops. Wheat, corn, alfalfa, and sorghums are the main crops grown. Small areas are in native grass and are used as range where they are part of range areas.

The main concern of management is the limited crop production caused by lack of soil moisture in some years.

Where this soil is irrigated, yields are higher than in nonirrigated areas. If nonirrigated crops are grown, crop residue management, including stubble mulching, is needed to control soil blowing and conserve moisture. In some years summer fallowing is also needed to store moisture. Land leveling, use of underground pipes, and careful management of irrigation water help to control erosion and evaporation on irrigated land. These practices also insure uniform penetration of water. Fertilizer should be applied to maintain a high level of fertility. This soil is irrigated along the North Fork of the Solomon River. It produces large amounts of forage when properly managed.

This soil has slight limitations for recreational or urban developments. Capability unit I-1, dryfarmed and irrigated; Loamy Terrace range site; windbreak group 1.

Rp—Roxbury silt loam, frequently flooded. This is a nearly level soil on flood plains of large streams and upland drainageways. Areas are narrow and are continuous in length along the drainageways. Slope is 0 to 1 percent.

Included with this soil in mapping are small areas in which the carbonates are leached to greater depths. On the flood plains along the North Fork of the Solomon River, the depth to sandy and loamy strata ranges from 42 to 60 inches.

Runoff is slow, and flooding is a hazard. Flooding is frequent, but scouring in channels and deposition of soil material take place only after there is a large amount of rainfall upstream.

This soil is suitable for forage grasses used as range or hay meadow. It is used for crops and range. Alfalfa and forage crops of corn and sorghum are the most commonly grown crops. Wheat may be damaged by spring flooding. When this soil is used for range, yields of forage are high.

The main concerns of management are controlling floods, conserving soil moisture, and maintaining tilth. Among the effective practices are using crop residue and fertilizer. Nitrogen and phosphorus are probably the only fertilizers needed.

This soil has severe limitations for recreational and urban developments. Capability unit IIIw-1, dryfarmed; Loamy Lowland range site; windbreak group 1.

Rr—Roxbury-Armo complex, 0 to 3 percent slopes. These are nearly level to gently sloping soils that formed in deep alluvium on fans. This complex is about 50 percent Roxbury silt loam, 35 percent Armo loam, and 15 percent other soils.

Included with this unit in mapping are small areas of Hord, McCook, and New Cambria soils and soils that are similar to Armo soil but stratified with layers of limestone gravel 3 to 4 inches thick and loamy layers 8 to 10 inches thick. Also included are small areas of a soil that is similar to Armo soil, but that formed in silty sediments and lacks the limestone gravel. Small gravelly areas are shown on the map by the symbol for a gravelly spot.

Surface runoff is medium to slow, and the hazard of erosion is slight. Erosion is the main hazard in the more sloping areas. Soil blowing is a hazard, and conservation of water can be a problem.

These soils are well suited to all locally grown crops and grasses. They are suited to irrigation where water of suitable quality is available.

Most areas of these soils are used for crops, but some areas are in native grasses used as range and are generally a part of large range areas.

The main concern of management is runoff from higher lying soils. When this unit is farmed, terracing, use of waterways, and stubble mulching are needed to reduce erosion and conserve soil moisture. In places, diversions and careful management of water are needed to prevent flooding from nearby uplands.

If land is to be leveled, careful investigations should be made to determine the depth to gravelly limestone layers. Occasionally crops and irrigation installations are damaged by floodwaters from the uplands.

Bench leveling, use of underground pipes and gated pipes, and careful management of irrigation water are needed to further reduce erosion and to increase yields. Fertilizers should be applied to maintain fertility.

Areas in native grass produce high yields of forage when properly managed. Capability unit IIe-2, dryfarmed and irrigated; Roxbury part in Loamy Lowland range site and windbreak group 1; Armo part in Limy Upland range site and windbreak group 3.

Uly Series

The Uly series consists of deep, well drained, strongly sloping to steep soils on loess-capped uplands. These soils formed in silty loess. The native vegetation was short and mid grasses.

In a representative profile (fig. 17) the surface layer is grayish brown silt loam about 8 inches thick. The subsoil is light brownish gray silt loam about 16 inches thick. The underlying material is very pale brown silt loam.

Permeability is moderate, and the available water capacity is high. Fertility is high. Surface runoff is medium to rapid.

Uly soils are suited to cultivation if erosion is controlled. They are also suited to habitat for openland wildlife and are well suited to native grass range. The limitations for many nonfarm uses are moderate.

Most areas are in native grass range, but some areas of the less sloping soils are used for cultivated crops.

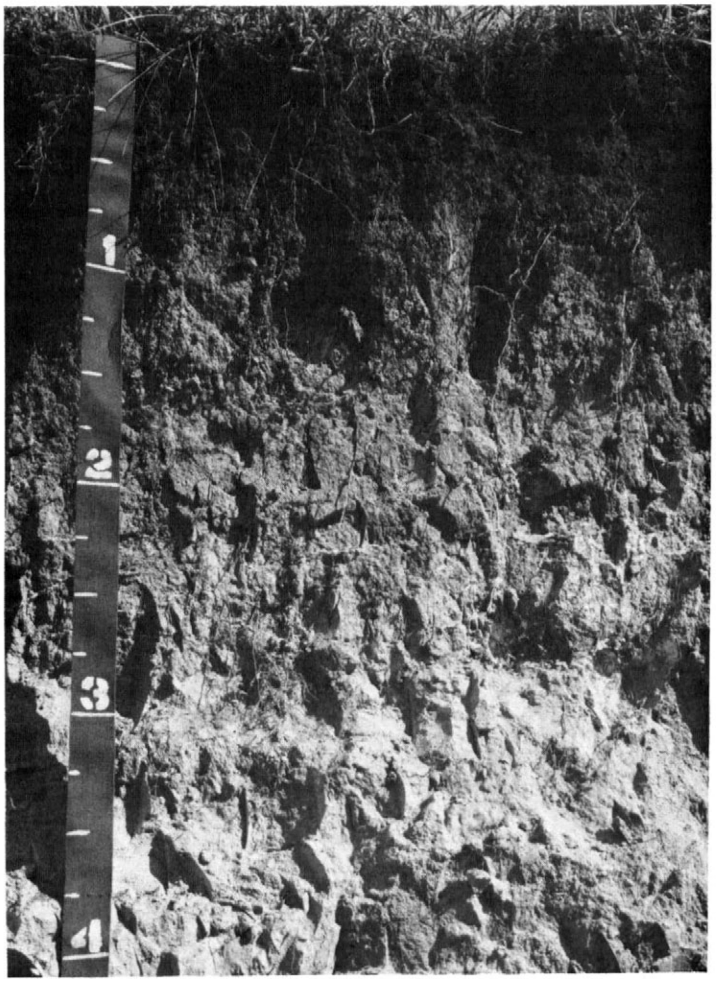

Figure 17.—**Representative profile of Uly silt loam.**

Representative profile of Uly silt loam, in an area of Uly-Holdrege silt loams, 7 to 12 percent slopes, in native grass, about 1,000 feet west and 200 feet north of the southeast corner of sec. 15, T. 1 S., R. 15 W.

A1—0 to 8 inches, grayish brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate fine granular structure; slightly hard, friable; many fine roots; numerous worm casts; slightly acid; gradual smooth boundary.

B2—8 to 16 inches, light brownish gray (10YR 6/2) heavy silt loam, dark grayish brown (10YR 4/2) when moist; moderate fine granular and weak fine subangular blocky structure; slightly hard, friable; few roots; neutral; gradual smooth boundary.

B3—16 to 24 inches, light brownish gray (10YR 6/2) silt loam, grayish brown (10YR 5/2) when moist; weak medium granular structure; slightly hard, friable; few fine roots; slight effervescence; mildly alkaline; gradual smooth boundary.

C—24 to 72 inches, very pale brown (10YR 7/3) silt loam, pale brown (10YR 6/3) when moist; weak fine granular structure; slightly hard, friable; strong effervescence; mildly alkaline.

The solum is slightly acid to mildly alkaline. The depth to free carbonates ranges from 12 to 24 inches.

The A1 horizon is grayish brown to light brownish gray and is 6 to 10 inches thick. The B2 horizon is light brownish gray or grayish brown silt loam to light silty clay loam. The C horizon is light gray to very pale brown.

Uly soils were mapped only with Holdrege or Roxbury soils. Uly soils are near Harney, Holdrege, Nuckolls, and Penden soils. They are less clayey than Harney soils. They are not leached as deeply as Holdrege soils, and they differ from Nuckolls soils in that they formed in younger, grayer loess. They are more silty and less sandy than Penden soils.

Uh—Uly-Holdrege silt loams, 7 to 12 percent slopes. These are strongly sloping soils on side slopes that are along drainageways on uplands. The complex is about 70 percent Uly silt loam and 30 percent Holdrege silt loam. Uly soils have the profile described as representative of the series.

Included with this unit in mapping are areas of an eroded soil that has a lighter colored surface layer. In some of the more eroded spots, limy subsoil material is exposed. In much of the cultivated acreage, tillage has mixed some of the subsoil material with the remaining original surface layer.

Runoff is rapid, and the hazard of erosion is severe. Soil blowing is a hazard where the soils do not have a rough surface or are not adequately protected by plant cover or crop residue.

These soils are not well suited to cultivation because of the erosion hazard. They are well suited to native grass. They are better suited to wheat than to other crops. They are suited to grain sorghum, but the sorghum is likely to be affected by chlorosis in the eroded areas.

These soils are in an intricate pattern of eroded, cultivated and native grass areas. About half of the acreage is cultivated and the rest is in native grasses. These areas are productive in years when rainfall is average or above average.

The main concern of management is controlling erosion. These soils can be cultivated only if soil blowing and erosion are controlled. Terracing, waterways, contour farming, stubble mulching, and summer fallow help control erosion, conserve and store moisture, and prevent soil blowing. Fertilizers should be applied to maintain fertility.

Good management is needed to maintain or improve the stand of range plants. Deferred grazing and rotation grazing are needed to produce adequate forage for livestock and also leave a protective cover on the soils. There are good sites on these soils for constructing dams to provide water for livestock.

These soils have moderate limitations for recreational or urban developments. Capability unit IVe-3, dryfarmed; Loamy Upland range site; windbreak group 2.

Ur—Uly-Roxbury silt loams, 0 to 30 percent slopes. The soils of this complex are on side slopes and flood plains in drainageways of the uplands. This complex is about 70 percent strongly sloping to steep Uly silt loam, 20 percent nearly level to gently sloping Roxbury silt loam, and 10 percent other soils, including Holdrege and Nuckolls silt loams.

The Uly soil has a profile similar to the one described as representative of the series, but the surface

layer is slightly thinner. The Uly soil formed in deep loess.

The Roxbury soil has a profile similar to the one described as representative of the Roxbury series, but it is dark to a slightly greater depth. Roxbury soils formed in deep calcareous alluvium. In places they have as much as 12 inches of light-colored silty sediment or are leached of free carbonates to a depth of 24 inches. Incised stream channels are also a part of this mapping unit.

Runoff is very rapid on the Uly soil, and the hazard of erosion is severe. Frequent flooding, which results in deposition of new sediments and channel scouring, is also a hazard. In cultivated areas, erosion has removed much of the original darkened surface layer, and fertility has been reduced. Plants that do not have a well developed root system are likely to be damaged by erosion.

This Uly soil is not suited to cultivation, and the areas of the Roxbury soil that are suited to cultivation are too small to map separately at the scale used. The soils are best suited to native grass range because of the hazards of erosion and flooding.

Most of this mapping unit is in range. Some trees grow in the lowlands. Some areas of the Roxbury soil are in alfalfa, sorghums, and corn. Some formerly cultivated areas have been seeded to native grass, and the rest should be reseeded and used as range.

Careful management is needed to produce yields of forage adequate for livestock and to provide cover to protect the soils. Management practices should include deferred grazing and rotation grazing and maintaining a proper stocking rate. Good management helps to maintain a good cover of grass, to increase the intake of water, and to conserve soil moisture.

There are many sites for dams or water impoundments. The limitations for recreational and urban developments are moderate to severe. Capability unit VIe-1, dryfarmed; Uly soils in Loamy Upland range site and windbreak group 2; Roxbury soils in Loamy Lowland range site and windbreak group 1.

Wakeen Series

The Wakeen series consists of moderately deep, well drained, sloping to moderately steep soils on uplands. These soils formed in material weathered from soft chalky shale. The native vegetation was mid and tall grasses.

In a representative profile the surface layer is dark grayish brown silt loam about 9 inches thick. In the upper part the subsoil is grayish brown, friable silty clay loam about 6 inches thick and in the lower part it is very pale brown, friable light silty clay loam about 19 inches thick. Soft chalky shale is at a depth of 34 inches.

Permeability is moderate, and the available water capacity is moderate. Fertility is medium.

The sloping Wakeen soils are suited to cultivation if erosion is controlled, but the steeper soils are better suited to native grasses used as range. These soils are suited to habitat for openland wildlife but are best suited to range because of slope, alkalinity, and depth to bedrock. The soil limitations for many nonfarm uses are moderate to severe.

Most areas of these soils are used for range, but some of the sloping areas are farmed.

Representative profile of Wakeen silt loam, 3 to 7 percent slopes, in a cultivated field, about 1,100 feet north and 100 feet east of the southwest corner of sec. 36, T. 3 S., R. 13 W.

A1—0 to 9 inches, dark grayish brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate medium granular structure; slightly hard, friable; many roots; numerous worm casts; slight effervescence; moderately alkaline; gradual smooth boundary.

B2—9 to 15 inches, grayish brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate fine granular structure; many roots; numerous worm casts; hard, friable; strong effervescence; moderately alkaline; clear smooth boundary.

B3—15 to 34 inches, very pale brown (10YR 7/3) light silty clay loam, pale brown (10YR 6/3) when moist; weak medium granular structure; hard, friable; much limy earth and soft chalky fragments in lower part; strong effervescence; mildly alkaline; clear smooth boundary.

C—34 to 72 inches, very pale brown (10YR 8/3) soft chalky shale.

The solum is mildly alkaline or moderately alkaline. The depth to underlying chalky shale ranges from 20 to 40 inches.

The A1 horizon is dark grayish brown to very dark gray silt loam or light silty clay loam and is 7 to 10 inches thick. The B2 horizon is light brownish gray to brown and is 6 to 10 inches thick. The C horizon ranges from pale brown to white.

Wakeen soils are near Armo, Brownell, Heizer, and Mento soils. Wakeen soils are more silty and less deep than Armo soils. Wakeen soils are underlain by soft chalky shale but Brownell soils are underlain by chalky limestone. Wakeen soils are deeper than Heizer soils and contain fragments that are less coarse. Wakeen soils contain free carbonates throughout but Mento soils are leached in the upper part of the solum. In addition, Wakeen soils are less clayey than Mento soils.

Wc—Wakeen silt loam, 3 to 7 percent slopes. This is a sloping soil on uplands in small to medium, irregularly shaped areas. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of Mento silt loam. The surface layer is silt loam and light silty clay loam. In some of the more eroded areas, shown on the soil map by the symbol for a severely eroded spot, light-colored limy subsoil material is exposed at the surface. In these areas, tillage has mixed some of the subsoil material with the remaining original surface layer.

Runoff is rapid, and the hazard of erosion is severe. Soil blowing is a hazard where the soil is not adequately protected by clods, vegetation, or crop residue.

This soil has low natural fertility. It is not well suited to cultivation because of high lime content and the serious hazard of erosion.

This soil is used for cultivated crops and range. It is better suited to wheat than to other crops, but it is more commonly used for sorghums. Especially in eroded areas, crops are affected by chlorosis. Alfalfa is also grown. Some small areas have been seeded to

native grass for use as range. The soil is more productive in years when rainfall is above average. In some cultivated areas erosion has removed much of the original surface layer and reduced the fertility.

The main concern of management is erosion. This soil can be cultivated safely only if erosion and soil blowing are reduced. Terracing, contour farming, waterways, stubble mulching, and summer fallow help control erosion, conserve and store moisture, and prevent soil blowing. Fertilizers should be applied to maintain fertility.

Good range management is needed to maintain or improve the stand of range plants. Deferred grazing and rotation grazing are needed to produce adequate forage for livestock and also leave a protective cover on the soils. The soil has good sites for constructing dams to provide water for livestock.

This soil has moderate to severe limitations for recreational or urban developments. Capability unit IVe-2, dryfarmed; Limy Upland range site; windbreak group 3.

Wd—Wakeen complex, 5 to 20 percent slopes. These are sloping to moderately steep soils on uplands. The complex is about 75 percent Wakeen silt loam and 25 percent Brownell gravelly loam and Heizer gravelly loam. Some of the Wakeen soils are about 15 inches deep over soft chalky shale and have a lighter colored surface layer than is defined as the range for the series.

Included with this unit in mapping are small areas of Alluvial land, loamy, and chalky shale outcrops. Places where materials have been quarried mainly for use as road surface material are shown by the symbol for mine quarries.

Surface runoff is rapid to very rapid, and the hazard of erosion is severe unless a grass cover is maintained. Fertility is low, and the root zone is restricted. The more chalky shale areas where little moisture penetrates, are barren, rough, broken, steep, and have vertical walls. Droughtiness, a restricted root zone, and low fertility limit the growth of plants in the shallow soils of this complex.

These soils are best suited to native grasses.

The main concerns of management are controlling erosion and improving range. Except for maintaining a good cover through controlled grazing, little can be done to protect these soils from erosion. Range management of the Wakeen soils includes planting suitable native grasses in areas now cultivated. Proper range use and deferred grazing protect the native grasses. Capability unit VIe-3, dryfarmed; Limy Upland range site; windbreak group 3.

Use and Management of the Soils

The soils of Smith County are used extensively for cultivated crops and native range. This section explains how the soils may be managed for these main purposes and also for windbreaks, wildlife, recreational sites, and in the building of highways, farm ponds, and other engineering structures. Also given are predicted yields of the principal crops under an improved level of management.

Effects of Erosion

Wind and water are the main causes of erosion in Smith County. Soil blowing is always a hazard and is serious during the recurring periods of drought. Strong winds and limited plant growth, which are characteristic of drought on the High Plains, are conducive to widespread soil blowing.

Water erosion is a hazard on all the sloping, cultivated soils. Runoff occurs during hard, driving thunderstorms when rain falls more rapidly than the water can enter the soil. Practices that slow down or decrease runoff help conserve moisture and control erosion.

Some effects of erosion are permanent. The soil may be damaged to the extent that it requires a change in use and management. Other effects are transitory, but they can impair the use of the land until restorative measures are taken.

During fieldwork on the soil survey, observations of the effects of erosion were made. Some of the observations were as follows:

Small, low hummocks and drifts of soil form on nearly level and smoothly sloping cultivated fields where active soil blowing is in progress. These hummocks and drifts blow again unless they are smoothed out and soils tilled to provide a rough surface that is resistant to erosion. Full use of the area can be restored and permanent soil damage prevented if the surface is roughened, as needed by additional tillage.

Within the more undulating High Plains tableland, the tops of ridges and knolls are more vulnerable to wind action than areas of adjacent, nearly level soils. Soil in exposed areas tends to blow more often; consequently, much of it has been deposited on smoother areas nearby. Some of the finer soil particles are transported great distances by the wind. Much of the silty and loamy material deposited on the adjacent areas is calcareous. Calcareous silty and clayey soils blow readily; therefore, soil blowing can occur after this material is deposited in a field that otherwise would be stable.

Soil can drift from actively eroding cultivated fields onto adjacent range and damage or destroy native vegetation. There is no permanent damage, but the use of the land is impaired until the grass has become reestablished either by deferred grazing or by reseeding.

During periods of drought, overuse of some of the very clayey, nonarable range can result in the loss of protective vegetation and severe soil blowing. These areas are thus permanently damaged, and their value for grazing is greatly reduced. Damage to cultivated crops and grass in adjacent areas is caused by drifting clayey material. The clayey sediments also increase the hazard of soil blowing on the soils on which they are deposited.

During flooding, erosion and some scouring and deposition occur on the low flood plains of the streams that are on Alluvial land, loamy. Some deposits also form on Roxbury soils on the nearly level flood plains of the upland drainageways.

Erosion is serious, not only when it results in per-

manent modification of the soil but also when it causes short-term damage to crops and forage. Replanting of crops, reseeding of range, and emergency tillage and smoothing operations can correct most of the temporary effects of erosion and restore full use of the land, but these practices are time consuming and costly.

Measures needed to control erosion vary according to the kind of soil, the degree of slope, and land use. One can generally choose a combination of practices that control erosion at a particular time (fig. 18). Some practices are suggested for each mapping unit in the section "Descriptions of the Soils." For more specific and detailed information on the control of erosion, consult a representative of the Soil Conservation Service.

Management of the Soils for Dryfarmed Crops[2]

In Smith County the management of soils for dryfarmed crops involves a combination of practices that reduces erosion and soil blowing, helps maintain good soil structure and an adequate organic matter content, and conserves as much rainfall as possible. Erosion control and water conservation are most successful if a proper combination of practices is used.

Terracing and contour farming can be used to reduce erosion and help conserve rainfall on most of the sloping soils in the county. These practices, alone or in combination, can also benefit some nearly level soils that have long slopes. Each row planted on the contour acts as a miniature terrace by holding back water and letting it soak into the soil. The water that is saved by terracing and contour farming increases crop growth, which in turn adds to the amount of residue available to protect the soil.

Crop residues should be properly managed on all of the soils in Smith County. Proper management of crop residues helps maintain good soil structure and control the infiltration of water, and helps control both erosion and soil blowing. A cover of residue on the surface helps hold the soil in place and helps reduce the puddling effect of beating raindrops.

Minimum or reduced tillage helps prevent the breakdown of soil aggregates and maintain more residue on the surface. Tilling when the soil is too wet causes a tillage pan to form, particularly in the loam and silt loam soils.

[2] By EARL J. BONDY, conservation agronomist, Soil Conservation Service, Salina.

Figure 18.—Grain sorghum planted on the contour on Holdrege silt loam, 3 to 7 percent slopes. Terraces in this field drain into the grassed waterway.

Stripcropping is another measure that can be used to control soil blowing. Stripcropping is generally used in combination with good crop residue management, minimum tillage, and the addition of fertilizer. Stripcropping is especially applicable to some of the nearly level soils that have a surface layer of sandy loam or loam.

Wheat and grain sorghum are the main crops grown in Smith County. Some alfalfa is also grown on bottom land but sometimes on uplands. Forage sorghum is grown as well. The sequence of crops that are grown affects the combination of practices that is needed for a particular soil.

Close-growing crops, such as wheat, provide more protection for the soil than row crops. Also, the residues from wheat provide more protection than the residues from grain sorghum.

Management of the Soils for Irrigated Crops[3]

The factors to be considered in planning an irrigation system are the characteristics and properties of the soil, the quality and quantity of irrigation water available, the crops to be irrigated, and the type of system to be used for irrigation. It is especially important to know the quality of the irrigation water in order to evaluate the long-term effect of irrigation on the soil.

All natural waters used for irrigation contain some soluble salts. If water of poor quality is used on a soil having slow permeability, and if some leaching is not done, harmful salts are likely to accumulate. Leaching requires an application of water in excess of the needs of the crops so that some of the water can pass through the root zone.

Some of the soil factors that are important to irrigation are depth, available water capacity, permeability, drainage, slope (fig. 19), and susceptibility to stream overflow. All of these must be considered in designing the irrigation system. The frequency of irrigation depends on the requirements of the crop and the available water capacity of the soil. The available water capacity is determined mainly by the depth and texture of the soil. Permeability affects the water-intake rate and the internal drainage of the soil. The rate of water intake is also affected by the condition of the surface layer.

[3] By EARL J. BONDY, conservation agronomist, Soil Conservation Service, Salina.

Figure 19.—These Holdrege soils have been leveled to grade for better management of irrigation water.

This survey has determined the characteristics of each soil in the county. Permeability and available water capacity for each soil are listed in the table on estimated soil properties in the section "Engineering." Soil features affecting the use of soils for irrigation are given in another table in this same section.

Wheat, corn, grain sorghum, and alfalfa are the main crops grown under irrigation in Smith County.

Capability Grouping

Some readers, particularly those who farm on a large scale, may find it practical to use and manage alike some of the different kinds of soil on their farms. These readers can make good use of the capability classification system, a grouping that shows, in a general way, the suitability of soils for most kinds of farming.

The grouping is based on permanent limitations of soils when used for field crops, the risk of damage when they are farmed, and the way the soils respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops that require special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations for range, for forest trees, or for engineerng.

In the capability system, all kinds of soil are grouped at three levels: the class, the subclass, and the unit. The broadest grouping, the capability class, is designated by Roman numerals I to VIII. In class I are the soils that have the fewest limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater natural limitations. In class VIII are soils and landforms so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products. The subclass indicates major kinds of limitations within the classes. Within most of the classes there can be up to 4 subclasses. The subclasses are indicated by adding a small letter, e, w, s, or c, to the class numeral, for example, IIe. The letter "e" shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; "w" means that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage) ; "s" shows that the soil is limited mainly because it is shallow, droughty, or stony; and "c" indicates that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few or no limitations. Class V can contain, at the most, only subclasses w, s, and c, because the soils are subject to little or no erosion but have other limitations that confine their use largely to pasture, range, or wildlife.

Subclasses are further divided into groups called capability units. These are groups of soils that are so much alike that they are suited to the same crops and pasture plants, they require about the same management, and they have generally similar productivity and other response to management. Capability units are generally identified by numbers assigned locally, for example, IIe-1 or VIIs-1.

The eight classes in the capability grouping system and the subclasses and units in Smith County are described in the list that follows. The capability unit of each soil in the county is listed in the "Guide to Mapping Units."

Class I. Soils have few limitations that restrict their use.

(No subclasses.)

Unit I-1. Deep, nearly level to slightly undulating, well drained silt loams that have moderate permeability, high available water capacity, good intake rate; on terraces.

Unit I-2. Deep, nearly level, well drained silt loams that have moderately slow permeability, high available water capacity; on uplands.

Class II. Soils have moderate limitations that reduce the choice of plants or require moderate conservation practices.

Subclass IIe. Soils subject to moderate erosion unless protected.

Unit IIe-1. Deep, gently sloping, well drained silt loams that have a subsoil of light silty clay loam, moderate permeability, high available water capacity; on uplands.

Unit IIe-2. Deep, nearly level to gently sloping, well drained silt loams and loams that have moderate permeability, high available water capacity; on fans and terraces.

Unit IIe-3. Deep, gently sloping, well drained silt loams and silty clay loams that have a subsoil of silty clay loam, moderately slow permeability, high available water capacity; on uplands.

Subclass IIw. Soils moderately limited because of occasional flooding.

Unit IIw-1. Deep, nearly level, well drained silt loams and fine sandy loams; on lowlands.

Subclass IIs. Soils moderately limited because of slow permeability.

Unit IIs-1. Deep, nearly level, moderately well drained silty clay loams or silty clays that have slow permeability, moderate available water capacity, low infiltration rate; on terraces.

Subclass IIc. Soils moderately limited because of climate or rainfall.

Unit IIc-1. Deep, nearly level, well drained silt loams that have moderately slow permeability; on uplands.

Class III. Soils have severe limitations that reduce

the choice of plants, require special conservation practices, or both.

Subclass IIIe. Soils subject to severe erosion if they are cultivated and not protected.

Unit IIIe-1. Deep, sloping, well drained silt loams; on uplands.

Unit IIIe-2. Deep, sloping, well drained, calcareous loams on fans and terraces.

Unit IIIe-3. Deep, sloping, well drained, eroded silty clay loams; on uplands.

Unit IIIe-4. Deep, sloping, well drained, calcareous loams; on uplands.

Subclass IIIw. Soils limited for cultivation because of excess flooding.

Unit IIIw-1. Deep, nearly level, well drained silt loam; in lowland swales.

Class IV. Soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Subclass IVe. Soils subject to very severe erosion if they are cultivated and not protected.

Unit IVe-1. Deep, sloping, well drained silt loams that have a subsoil of silty clay loam; on uplands.

Unit IVe-2. Moderately deep, sloping, well drained, calcareous silt loams over soft chalky shales; on uplands.

Unit IVe-3. Deep, strongly sloping, well drained silt loams on uplands.

Unit IVe-4. Deep, nearly level and gently sloping, well drained to somewhat excessively drained loamy fine sands and fine sandy loams; on uplands.

Class V. Soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture or range, woodland, or wildlife habitat.

Subclass Vw. Deep soils on low flood plains that have meandering channels subject to frequent overflow.

Unit Vw-1. Deep, nearly level, channeled, moderately well drained to well drained silty soils; on lowlands.

Class VI. Soils have severe limitations that make them generally unsuitable for cultivation and limit their use largely to pasture, range, woodland, or wildlife habitat.

Subclass VIe. Soils that are severely limited, chiefly by risk of erosion, unless protective cover is maintained.

Unit VIe-1. Deep, nearly level to steep, well drained silt loams; in drainageways; on uplands and lowlands.

Unit VIe-2. Moderately deep and shallow, sloping to steep, well drained and somewhat excessively drained loams; on uplands.

Unit VIe-3. Moderately deep, sloping to moderately steep, well drained silt loams over chalky shales; on uplands.

Unit VIe-4. Moderately deep, sloping to strongly sloping, well drained gravelly loams over limestone; on uplands.

Unit VIe-5. Moderately deep, sloping to strongly sloping, moderately well drained clays; on uplands.

Class VII. Soils have very severe limitations that make them unsuitable for cultivation and restrict their use largely to range, woodland, or wildlife food and cover.

Subclass VIIs. Soils that are very severely limited, chiefly by stoniness and risk of erosion, unless protective cover is maintained.

Unit VIIs-1. Shallow and moderately deep, strongly sloping to steep, well drained and somewhat excessively drained gravelly loams; on uplands.

Class VIII. (None in county.) Soils and landforms have limitations that preclude their use for commercial crop production and restrict their use to recreation, wildlife habitat, water supply, or esthetic purposes.

Predicted Yields

The predicted average yields per acre that can be expected for the principal crops grown in the county are shown in tables 2 and 3. These yields do not apply to any specific field in any particular year. Rather, they indicate what can be expected as an average yield over a period of years. The estimates in the table were made on the basis of information obtained from local farmers, various agricultural agencies, demonstration plot, and research data.

Only the soils commonly used for dryfarmed crops are listed in table 2. The predicted yields are for a high level of management. This management includes the following:

1. Crop varieties suited to the area.
2. Proper seeding rates; suitable and timely methods of planting and harvesting.
3. Full and timely practices for controlling weeds, diseases, and insects.
4. Timely tillage.
5. Fertility program based on requirements for optimum efficiency in crop production.
6. Use of terraces, contour farming, grassed waterways, stubble-mulch tillage, and summer fallow to conserve moisture and control runoff.
7. Use of cropping systems and crop residue management to control erosion, soil blowing, and to keep the soil in good physical condition.
8. Manure, when available, to maintain the content of organic matter.

Only the soils commonly used for irrigated crops are listed in table 3. The predicted yields are for a high level of management. This management includes the following:

1. The irrigation system provides for uniform penetration of water and the control of ero-

TABLE 2.—*Predicted yields per acre of dryfarmed crops*

[Soils not listed in this table are not suitable for the crops shown.]

Soil	Wheat	Grain sorghum	Alfalfa hay
	Bu	*Bu*	*Tons*
Armo loam, 2 to 7 percent slopes	26	39	2.2
Harney silt loam, 0 to 1 percent slopes	38	54	3.2
Harney silt loam, 1 to 3 percent slopes	34	51	3.0
Harney-Mento silt loams, 3 to 7 percent slopes	24	33	1.8
Holdrege silt loam, 1 to 3 percent slopes	34	51	3.0
Holdrege silt loam, 3 to 7 percent slopes	28	42	2.4
Holdrege silty clay loam, 3 to 7 percent slopes, eroded	26	42	2.4
Hord silt loam	40	60	4.0
Inavale-Munjor complex	20	30	1.6
McCook silt loam	38	54	4.0
McCook-Munjor complex	34	48	3.2
New Cambria silty clay	32	45	3.0
Nuckolls silt loam, 7 to 12 percent slopes	24	33	2.0
Nuckolls-Holdrege silt loams, 3 to 7 percent slopes	32	48	3.6
Penden loam, 3 to 7 percent slopes	26	36	2.4
Roxbury silt loam	38	60	4.0
Roxbury silt loam, frequently flooded	28	48	2.2
Roxbury-Armo complex, 0 to 3 percent slopes	36	54	3.4
Uly-Holdrege silt loams, 7 to 12 percent slopes	22	33	2.0
Wakeen silt loam, 3 to 7 percent slopes	24	30	1.6

TABLE 3—*Predicted yields per acre of irrigated crops*

Soil	Corn	Grain sorghum	Alfalfa
	Bu	*Bu*	*Tons*
Harney silt loam, 0 to 1 percent slopes	126	124	5.4
Harney silt loam, 1 to 3 percent slopes	112	117	5.4
Holdrege silt loam, 1 to 3 percent slopes	126	117	5.4
Hord silt loam	133	130	6.0
McCook silt loam	140	124	6.0
McCook-Munjor complex	126	110	5.4
New Cambria silty clay	91	98	4.8
Roxbury silt loam	140	130	6.0
Roxbury-Armo complex, 0 to 3 percent slopes	126	117	5.4

sion. Land leveling, contour furrowing, and the use of gated pipes and underground pipes are among the practices used.

2. The soils are tilled at the proper time.
3. The cropping system includes legumes, close-growing crops, and row crops.
4. Suitable varieties of crops are planted.
5. Seeding is at a rate that insures a maximum plant population.
6. Irrigation water is applied properly.
7. The amounts and kinds of fertilizer applied provide the level of fertility needed to produce optimum yields of the particular crop.
8. Manure, when available, is used to maintain the content of organic matter.

Range[4]

Much of the agricultural income in Smith County is from the sale of livestock and livestock products. According to the 1969 Farm Facts, Kansas Crop and Livestock Information, about 41 percent of the annual gross income from farms and ranches in the county was from the sale of beef cattle, sheep, and dairy products. The number of cattle, including calves, in the county generally ranges from 60,000 to 80,000.

The major source of livestock feed is native range, but large amounts of crops and their byproducts are used for supplemental feed. Approximately 38 percent of the land area in the county, or 210,568 acres, is range.

In addition to producing pasture and hay for livestock, range supplies food and cover for wildlife. Well managed range contributes to flood control when large amounts of the precipitation that falls soak into the root zone. Range has esthetic values, providing a wide array of flowering plants that bloom at various times throughout the summer.

Range sites and condition classes

Effective range management requires knowledge of

[4] HARLAND E. DIETZ, range conservationist, Soil Conservation Service, Salina.

the capabilities of the various soils, the combinations of plants that can be produced, and the effects of grazing on the different kinds of plants. The ability to recognize signs of improvement or deterioration in the range vegetation is also important. A system for recording and evaluating range resources is discussed in the following paragraphs.

There are many differences in the soils and climate of Smith County. For this reason there are several different kinds of range recognized. These different kinds of range are called range sites.

Over the centuries, the plants best adapted to a range site have become established on the site. This group of plants is called the potential or climax plant community for the site. The climax plant community for a site varies slightly from year to year, but the kinds and amounts of plants remain about the same if undisturbed.

The original mixture of plants fitted the soil and climate of the range site so perfectly that other kinds of plants could not move in unless an area was disturbed. So consistent is the relationship between plants, climate, and soils that the climax plant community can be accurately predicted, even on severely disturbed sites, if the soil is identified.

Range conservationists and soils scientists, working together, group into range sites those soils which naturally grow the same climax plant communities.

Repeated overuse by grazing animals, excessive burning, or plowing causes changes in the kinds, proportions, or amounts of climax plants in the plant community. Depending on the kind and degree of disturbance, some kinds of plants increase while others decrease. If the disturbance is severe, plants that do not belong in the climax plant community can invade. Plant response to grazing depends on the kind of grazing animal, the season of use, and how closely the plant is grazed. If good management follows disturbances, however, the climax plant community is gradually reestablished unless soils have been seriously eroded.

Range condition is an expression of how the present plant community compares with the climax plant community for the range site. The more similar the present kinds and amounts of plants are to the climax plant mixture, the better the range condition.

To indicate the degree to which the vegetation on a range site has deteriorated from its potential, the following four classes of range condition are recognized:

Excellent condition—76 to 100 percent of the present vegetation is of the same composition as the original or climax vegetation for the range site.

Good condition—51 to 75 percent of the present vegetation is of the same composition as the original vegetation.

Fair condition—26 to 50 percent of the present vegetation is of the same composition as the original vegetation.

Poor condition—Less than 25 percent of the present vegetation is of the same composition as the original vegetation.

Knowledge of the climax plant communities of range sites and of the nature of present plant communities in relation to that potential is important in planning and applying conservation measures. Such information is the basis for selecting management objectives, designing grazing systems, managing wildlife, determining potential for recreation, and rating watershed conditions.

Any management objective for rangeland must provide for a plant cover that adequately protects or improves the soil and water resources and meets the needs of the operator. This usually involves maintaining or increasing desirable plants and restoring a degraded community to near climax conditions. Sometimes, however, a plant cover somewhat below climax better fits specific grazing needs, provides better wildlife habitat, or furnishes other benefits while still protecting the soil and water resources.

Descriptions of range sites

On the following pages, the range sites of Smith County are described and the climax plants are listed for each site. Plant species most likely to invade are also shown. In addition, an estimate of the potential annual production of air-dry vegetation is indicated for each site. The soils in each range site may be determined by referring to the "Guide to Mapping Units" at the back of this soil survey.

BLUE SHALE RANGE SITE

The only soil in this range site is Bogue clay, 3 to 15 percent slopes. It is sloping to strongly sloping and moderately deep and has a clay texture throughout the profile. Abundant fractures are common in the subsoil, allowing deep penetration of water and plant roots. Permeability is very slow, and penetration is impeded. The available water capacity is moderate, and fertility is low. This soil is subject to severe erosion and soil blowing unless grazing is carefully regulated.

The climax plant community, by weight, is 35 percent big bluestem. Little bluestem and sideoats grama each makes up 15 percent; western wheatgrass makes up 10 percent; indiangrass, blue grama, and buffalograss each makes up 5 percent; tall dropseed and leadplant each makes up 3 percent; and switchgrass and blacksamson each makes up 2 percent.

Continuous overgrazing changes the plant community. The preferred plants, including big bluestem, little bluestem, switchgrass, and leadplant, are selectively grazed by livestock. When repeatedly overgrazed, these plants are weakened and gradually decrease in abundance. The less palatable plants, including tall dropseed, sideoats grama, blue grama, buffalograss, western ragweed, and Louisiana sagewort, increase.

If the site is overgrazed for many years, the vegetation degenerates to mainly blue grama, buffalograss, red three-awn, western ragweed, common pricklypear, and broomweed.

If this site is in excellent condition, the average annual production of air-dry herbage is 3,000 pounds

per acre in years of favorable moisture and 1,000 pounds per acre in years of unfavorable moisture.

CLAY TERRACE RANGE SITE

The only soil in this range site is New Cambria silty clay. It is a nearly level, deep, alluvial soil on benches or terraces. The surface layer ranges from silty clay loam to silty clay, and the subsoil ranges from light silty clay to dense clay. Permeability is slow in the subsoil, and plant root penetration is impeded. Runoff water from nearby uplands provides some additional moisture, but flooding is infrequent. The available water capacity is moderate.

The climax plant community, by weight, is 30 percent big bluestem, 15 percent switchgrass, and 10 percent western wheatgrass. Little bluestem, Canada wildrye and Virginia wildrye, blue grama, tall dropseed, and Maximilian sunflower each makes up 5 percent; woody plants make up 5 percent; sideoats grama and Illinois bundleflower each makes up 3 percent; and carex and wholeleaf rosinweed each makes up 2 percent.

Prolonged overgrazing changes the plant community. The taller grasses, including big bluestem, indiangrass, switchgrass, wildrye, and little bluestem, decrease in amount. Plants such as western wheatgrass, sideoats grama, blue grama, sedges, and tall dropseed increase. Palatable forbs, Maximilian sunflower, wholeleaf rosinweed, and Illinois bundleflower also decrease if the site is subjected to continuous overgrazing. Only minor amounts of Louisiana sagewort, Baldwin ironweed, western ragweed, and tall goldenrod are in the plant communities, but they increase rapidly if the site is overgrazed. If the site has been overgrazed for many years, the vegetation is mainly blue grama, buffalograss, western wheatgrass and tall dropseed.

Woody plants are in favorable locations and increase in abundance with overgrazing. Common woody species include bur oak, elm cottonwood, ash, and hackberry.

If this site is in excellent condition, the average annual production of air-dry herbage is 4,500 pounds per acre in years of favorable moisture and 2,000 pounds per acre in years of unfavorable moisture.

LIMY UPLAND RANGE SITE

The soils in this range site are gently sloping to moderately steep, deep and moderately deep, and are on uplands. The surface layer is typically calcareous and well granulated. The rate of water intake is good, and sufficient moisture is available for plants. Armo, Brownell, Campus, Penden, and Wakeen soils are in this range site.

The climax plant community, by weight, is 25 percent big bluestem, 20 percent little bluestem, 10 percent sideoats grama, and 8 percent blue grama and hairy grama. Indiangrass, switchgrass, western wheatgrass, leadplant, Louisiana sagewort, and small soapweed each makes up 5 percent; prairieclover makes up 3 percent; and blacksamson and western ragweed each makes up 2 percent.

Continuous overgrazing changes the plant community. The preferred plants, including big bluestem, little bluestem, indiangrass, switchgrass, and leadplant, are selectively grazed by livestock. When repeatedly overgrazed, these plants are weakened and gradually decrease in abundance. The less palatable plants, including sideoats grama, blue grama, hairy grama, buffalograss, western ragweed, and Louisiana sagewort, increase.

If the site is overgrazed for many years, the vegetation degenerates to mainly blue grama, buffalograss, silver bluestem, western ragweed, and broomweed.

If this site is in excellent condition the average annual production of air-dry herbage is 4,000 pounds per acre in years of favorable moisture and 1,000 pounds per acre in years of unfavorable moisture.

LOAMY LOWLAND RANGE SITE

The soils in this range site are nearly level, deep, alluvial, and are on bottom lands along the rivers and major streams throughout the county. The surface layer is loamy or silty. The soils have a high capacity for root growth and moisture storage. Water tables on Munjor soils and Alluvial land, loamy, fluctuate to within 3 feet of the surface in some areas of the county. When present, these water tables have a favorable influence on plant growth. McCook, Munjor, and Roxbury soils, and Alluvial land, loamy, are in this range site.

The climax plant community, by weight, is 30 percent big bluestem. Indiangrass, switchgrass, and western wheatgrass each makes up 10 percent; and prairie cordgrass, little bluestem, Canada wildrye, tall dropseed. Maximilian sunflower, wholeleaf rosinweed, and carex each makes up 5 percent; woody plants make up 5 percent.

Prolonged overgrazing changes the plant community. The taller grasses, including big bluestem, indiangrass, switchgrass, and little bluestem, decrease in amount. Plants such as western wheatgrass, sideoats grama, blue grama, and tall dropseed increase. Palatable forbs, Maximilian sunflower, and wholeleaf rosinweed also decrease if the site is subjected to continuous overgrazing. Only minor amounts of heath aster, Baldwin ironweed, and tall goldenrod are in the plant communities, but they increase rapidly if the site is overgrazed.

If the site is overgrazed for many years, the vegetation deteriorates to buffalograss, tall dropseed, silver bluestem, Kentucky bluegrass, cocklebur, snow-on-the-mountain, and annual brome.

Woody plants are common along stream channels and increase in abundance with overgrazing. Common woody plants include cottonwood, elm, bur oak, and buckbrush.

If this site is in excellent condition, the average annual production of air-dry herbage is 6,000 pounds per acre in years of favorable moisture and 3,800 pounds per acre in years of unfavorable moisture.

LOAMY TERRACE RANGE SITE

The soils in this range site are deep, nearly level, and are on alluvial benches or terraces. The surface layer

and subsoil are silt loam. Permeability is moderate, and deep plant root penetration is possible. McCook, Hord, and Roxbury silt loam are in this range site.

The climax plant community, by weight, is 25 percent big bluestem and 15 percent switchgrass. Indiangrass, little bluestem, and western wheatgrass each makes up 10 percent; sideoats grama, blue grama, tall dropseed, and Maximilian sunflower each makes up 5 percent; Canada wildrye and slimflower scurfpea each makes up 3 percent; and Illinois bundleflower and western ragweed each makes up 2 percent.

Prolonged overgrazing changes the plant community. The taller grasses, including big bluestem, indiangrass, switchgrass, and little bluestem, decrease in amount. Plants such as western wheatgrass, sideoats grama, blue grama, and tall dropseed increase. Palatable forbs, such as Maximilian sunflower and Illinois bundleflower, also decrease if the site is subjected to continuous overgrazing. Only minor amounts of western ragweed, heath aster, Baldwin ironweed, and Missouri goldenrod are in the plant communities, but they increase rapidly if the site is overgrazed.

If this site is in excellent condition, the average annual production of air-dry herbage is 4,500 pounds per acre in years of favorable moisture and 2,500 pounds per acre in years of unfavorable moisture.

LOAMY UPLAND RANGE SITE

The soils in this range site are nearly level to steep, deep, and are on uplands. The surface layer is loamy, and the subsoil is loamy to clayey. Permeability is moderate to moderately slow. The available water capacity is high, and there is ample room for root growth. Holdrege (fig. 20), Nuckolls, Harney, and Uly soils are in this range site.

The climax plant community, by weight, is 25 percent big bluestem. Little bluestem, sideoats grama, blue grama, and western wheatgrass each makes up 10 percent; indiangrass, switchgrass, buffalograss, tall dropseed, and slimflower scurfpea each makes up 5 percent; western ragweed and Louisiana sagewort each makes up 3 percent; and prairie coneflower and dotted gayfeather each makes up 2 percent.

Continuous overgrazing changes the plant community. The preferred plants, including big bluestem, little bluestem, and switchgrass, are selectively grazed by livestock. When repeatedly overgrazed, these plants are weakened and gradually decrease in abundance. Plants that increase include sideoats grama, blue grama, buffalograss, western wheatgrass, western ragweed, and Louisiana sagewort.

If the site is overgrazed for many years, the vegetation degenerates to mainly blue grama, buffalograss, windmillgrass, and western ragweed.

If this site is in excellent condition, the average annual production of air-dry herbage is 4,000 pounds per acre in years of favorable moisture and 1,000 pounds per acre in years of unfavorable moisture.

SANDS RANGE SITE

Only Inavale soils are in this range site. They are on undulating to rolling topography. The surface layer

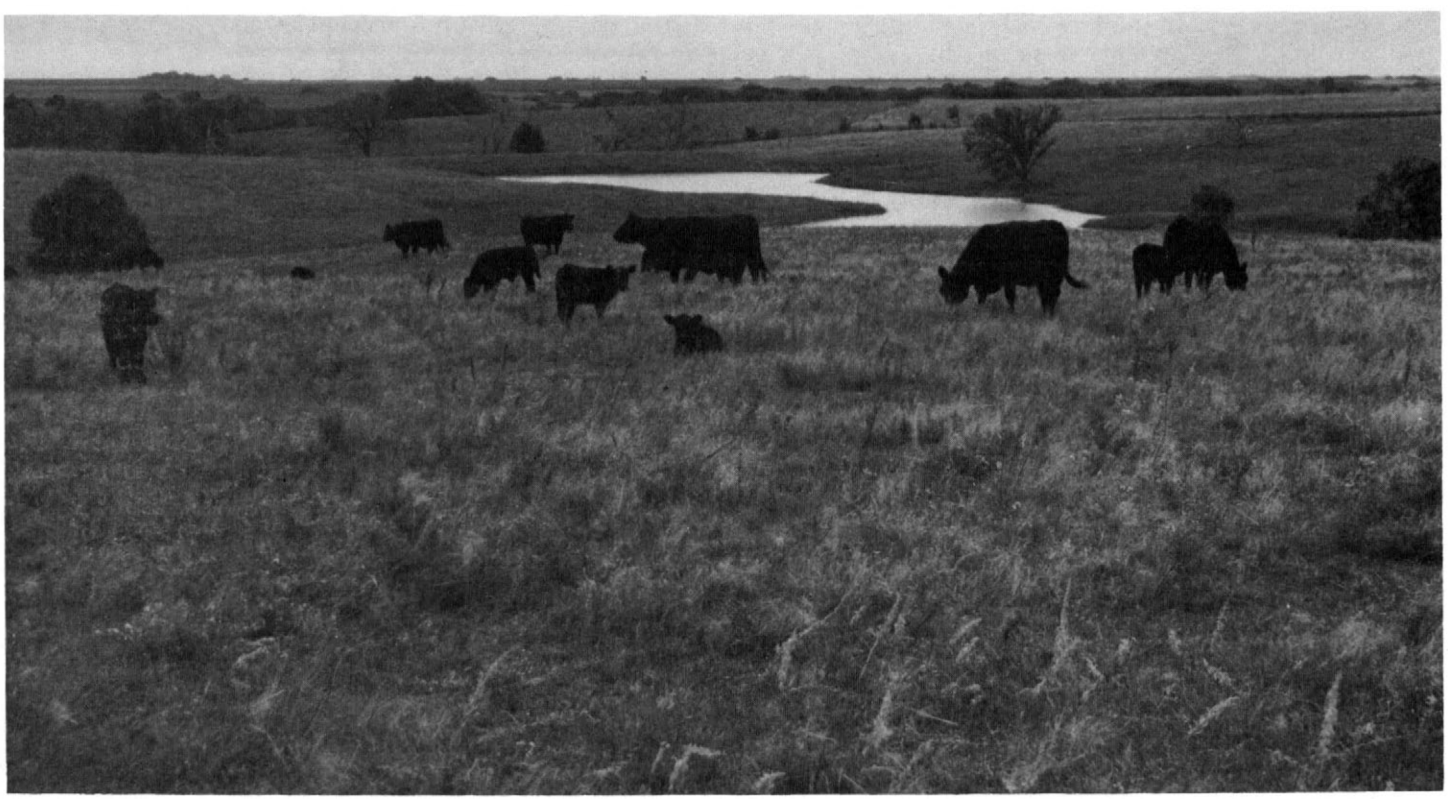

Figure 20.—Cattle grazing on Holdrege soils in the Loamy Upland range site.

and subsoil are fine sand. These soils absorb moisture rapidly, but their available water capacity is low.

The climax plant community, by weight, is 30 percent sand bluestem and 20 percent little bluestem. Switchgrass and blue grama each makes up 10 percent; indiangrass, Illinois bundleflower, Louisiana sagewort, and sand plum each makes up 5 percent; sideoats grama and Scribner's panicum each makes up 3 percent; and sand dropseed and roundhead lespedeza each makes up 2 percent.

Prolonged overgrazing changes the plant community. The taller grasses, including sand bluestem, indiangrass, switchgrass, and little bluestem, decrease in amount. Plants such as blue grama, fall witchgrass, Scribner's panicum, sand paspalum, and sand dropseed increase. Palatable forbs, roundhead lespedeza, and Illinois bundleflower also decrease if the site is subjected to continuous overgrazing. Only minor amounts of Louisiana sagewort, small soapweed, western ragweed, and Missouri goldenrod are in the plant communities, but they increase if the site is overgrazed.

Continuous overgrazing for many years results in the invasion of annual plants such as sandbur, annual eriogonum, and camphorweed.

If this site is in excellent condition, the average annual production of air-dry herbage is 4,000 pounds per acre in years of favorable moisture and 2,500 pounds per acre in years of unfavorable moisture.

SANDY RANGE SITE

Only Munjor soils are in this range site. They are deep, nearly level to gently sloping, and are on flood plains. The surface layer is fine sandy loam that has a good rate of water intake, and the subsoil is sandy clay loam that stores a moderate amount of water. This site is productive when in good to excellent condition.

The climax plant community, by weight, is 25 percent sand bluestem and big bluestem, and 15 percent little bluestem. Switchgrass makes up 10 percent; blue grama and hairy grama make up 10 percent; indiangrass, western wheatgrass, Illinois bundleflower, sand plum, small soapweed, and Louisiana sagewort each makes up 5 percent; Scribner's panicum and slimflower scurfpea each makes up 3 percent; and sand dropseed and roundhead lespedeza each makes up 2 percent.

Prolonged overgrazing changes the plant community. The taller grasses, including sand bluestem, indiangrass, switchgrass, and little bluestem, decrease in amount. Plants such as western wheatgrass, hairy grama, sand paspalum, purple lovegrass, blue grama, and sand dropseed increase. Only minor amounts of Louisiana sagewort, common pricklypear, western ragweed, and goldenrod are in the plant communities, but they increase if the site is overgrazed.

If this site is in excellent conditon, the average annual production of air-dry herbage is 4,000 pounds per acre in years of favorable moisture and 2,000 pounds per acre in years of unfavorable moisture.

SHALLOW LIMY RANGE SITE

The soils in this range site are strongly sloping to steep and are on uplands. The surface layer is loamy and ranges from 4 to 20 inches in depth over limestone. Permeability is moderate, and available water capacity is low and very low. Plant root penetration is limited by limestone and hard caliche in the subsoil. The soils are generally rough and broken and have many vertical ledges which make travel for livestock difficult. Canlon and Heizer soils are in this range site.

The climax plant community, by weight, is 25 percent little bluestem, 20 percent big bluestem, and 15 percent sideoats grama. Plains muhly makes up 10 percent; blue grama and hairy grama make up 10 percent; switchgrass makes up 5 percent; leadplant makes up 3 percent; and resinous skullcap, blacksamson, prairieclover, catclaw sensitivebrier, smooth sumac, and small soapweed each makes up 2 percent.

Continuous overgrazing changes the plant community. The preferred plants, including big bluestem, little bluestem, plains muhly, switchgrass, and leadplant, are selectively grazed by livestock. When repeatedly overgrazed, these plants are weakened and gradually decrease in abundance. The less palatable plants, including sideoats grama, blue grama, hairy grama, buffalograss, and western ragweed, increase.

If the site is overgrazed for many years, the vegetation degenerates to mainly sideoats grama, blue grama, hairy grama, buffalograss, silver bluestem, western ragweed, and broom snakeweed.

If this site is in excellent condition, the average annual production of air-dry herbage is 2,500 pounds per acre in years of favorable moisture and 800 pounds per acre in years of unfavorable moisture.

Windbreaks

Smith County has no large areas of woodland, though there are open stands of hardwoods bordering the streams. The trees seldom grow large enough to be of commercial value, but they are used for fuel, fenceposts, and food and cover for wildlife. A few black walnut trees have been harvested for commercial uses.

The greatest use of trees and shrubs in the county is in windbreaks, which generally are around farmsteads (fig. 21). Native trees and shrubs that can be planted in windbreaks are bur oak, green ash, black walnut, hackberry, cottonwood, wild plum, and chokecherry. Any of these trees or shrubs can be put in windbreaks made up mostly of imported trees and shrubs.

Windbreaks require careful planning and special management, and they should be shaped to fit their particular area. The trees and shrubs should be selected according to their suitability for the different kinds of soils, and they should be planted in an area that has been cleared of vegetation.

Some practices that are beneficial for windbreak management are residue management, weed control, and terracing. Management of residue by stubble mulching and proper cultivation controls weeds, reduces erosion, and conserves moisture.

Cultivating or spraying keeps out weeds. The young

Figure 21.—**Farmstead windbreak on Roxbury soils. These soils are in windbreak suitability group 1.**

trees need protection from fire, livestock, insects, rabbits, and rodents. Grasses and weeds must be controlled to prevent competition for available moisture. Cultivation controls weeds and also permits water and air to penetrate the soils easily. Extra moisture can be provided by diverting runoff from other areas, by diverting floodwaters, and by using water from irrigation and domestic wells. In some areas irrigation causes new windbreaks to grow faster and develop a good root system early.

Windbreak suitability groups

The soils of Smith County have been placed in three windbreak suitability groups according to their suitability for trees and shrubs. The suitability of each group for named species is rated in table 4. The three suitability groups are lowland, upland, and limy upland. Each windbreak group consists of soils that are suitable for about the same kinds of trees and shrubs—those that require similar management and have the same chance of survival and growth rate.

The Bogue, Canlon, Heizer, and Inavale soils are not suitable for planting trees and are not placed in windbreak suitability groups.

Windbreak Suitability Group 1.—The soils in this suitability group are on nearly level terraces and drainageways of the lowlands. These soils receive extra moisture as runoff from nearby uplands and from flooding. The flood plains are best suited to trees because of the frequent stream overflow, but they are less suited to building sites and feed lots.

These soils mainly have a surface layer and subsoil of silt loam or silty clay loam. Permeability is moderately rapid to slow, and available water capacity is high or moderate. These soils are moderately well drained and well drained.

Windbreak Suitability Group 2.—The soils of suitability group 2 are on nearly level to strongly sloping uplands. These soils naturally receive only the moisture that falls as precipitation.

The surface layer is silt loam or loam, and the subsoil is heavy silt loam or silty clay loam. Permeability is moderate to moderately slow, and available water capacity is high. The soils are well drained.

Windbreak Suitability Group 3.—The soils of suitability group 3 are on gently sloping to strongly sloping uplands. These soils are deep to moderately deep over chalky shales and limestone.

The surface layer is silt loam or loam, and the subsoil is mainly silty clay loam or clay loam. The available water capacity is low to high. The soils are well drained.

In table 4 the suitability of the soils in each group is rated for specified trees and shrubs. The ratings are excellent, good, fair, and poor. A suitability rating of *excellent* indicates that trees grow well on the soils in the suitability group. Leaves have good color, there are few if any dead branches and little or no die-back in the upper part of the crown, and there is no indication of damage by fungus or disease.

A rating of *good* indicates that trees grow moderately well, there are a few dead branches and some die-back in the upper part of crown, and there is slight damage by fungi or insects.

A rating of *fair* indicates that at least half of the trees have a significant number of dead branches in the upper part of the crown, about one-fourth of the trees are dead, tree growth is slow, and moderate damage by fungi or insects can be expected.

A rating of *poor* indicates that surviving trees have severe die-back, less than three-fourths of trees planted survive, and severe damage by fungi and insects can be expected.

Wildlife[5]

The soils of Smith County provide suitable habitat for many kinds of animals and birds. The most important game birds are the ring-necked pheasant and the bobwhite quail. Alluvial soils, along the North Fork of the Solomon River and its tributaries, produce habitat for deer, raccoon, squirrel, muskrat, opossum, and songbirds.

Numerous farm ponds provide good to excellent fishing for bass, bluegill, channel catfish, and bullheads. The estimated annual fish production from farm ponds is 100 to 300 pounds per acre. This annual yield should be kept in mind when fishing a pond. All stocked species should be fished to maintain a balanced population. The North Fork of the Solomon River, its tributaries, and the large reservoirs in adjoining counties offer additional fishing opportunities.

The season for hunting pheasant and quail draws many hunters into the uplands. Both species are well suited to the croplands, pastures, and meadows of the county.

[5] ROBERT J. HIGGINS and JACK W. WALSTROM, biologists, Soil Conservation Service, Salina.

TABLE 4.—*Vigor and height of trees and shrubs by windbreak suitability group*

[Estimates of height are for 20-year-old trees. Vigor ratings are explained in the text. No estimate of height is given if vigor is rated poor]

Trees and shrubs	Group 1 (Lowlands)		Group 2 (Uplands)		Group 3 (Limy uplands)	
	Vigor	Height	Vigor	Height	Vigor	Height
		Feet		*Feet*		*Feet*
Coniferous trees:						
Eastern redcedar	Excellent	20–25	Excellent	20–25	Fair	15–20
Rocky Mountain juniper	Good	25–30	Good	20–25	Poor	
Ponderosa pine	Excellent	25–30	Excellent	20–25	Fair	15–20
Austrian pine	Excellent	25–30	Excellent	30–35	Fair	10–15
Tall deciduous trees:						
Cottonwood	Excellent	40–50	Fair	25–35	Poor	
Siberian elm	Excellent	25–45	Excellent	30–40	Good	25–35
Medium deciduous trees:						
Green ash	Excellent	30–35	Excellent	20–25	Fair	10–15
Hackberry	Excellent	30–35	Excellent	20–25	Good	15–20
Bur oak	Excellent	25–30	Excellent	20–25	Fair	10–15
Black walnut	Excellent	25–30	Good	20–25	Poor	
Honeylocust	Good	25–30	Excellent	20–25	Fair	15–20
Short deciduous trees:						
Russian-olive	Excellent	15–20	Excellent	15–20	Good	10–15
Russian mulberry	Excellent	15–20	Good	10–15	Fair	10–15
Osageorange	Excellent	15–20	Excellent	15–20	Fair	10–15
Shrubs:						
American plum	Excellent	5–10	Excellent	5–10	Good	2–6
Tamarisk	Excellent	5–10	Good	5–10	Poor	
Common lilac	Excellent	5–10	Excellent	5–10	Poor	
Multiflora rose	Good	3–8	Fair	3–5	Poor	

White-tailed deer are increasing in the county. During hunting seasons each fall hunters are allowed to harvest surplus animals. The best white-tailed deer habitat in Smith County is along the wooded streams. Some mule deer can also be seen.

Cottontail rabbits and fox squirrel are other species associated with the woodlands along the streams. Migrating waterfowl use farm ponds and the large reservoirs as resting places during their migration through Kansas. Large numbers of ducks and geese often overwinter on the large reservoirs throughout Kansas. Raccoon, beaver, skunk, opossum, and muskrat are furbearers commonly associated with wet and wooded areas of the county.

Songbirds, such as meadowlarks, robins, mourning doves, and cardinals, insect-eating birds, and hawks and other birds of prey also live in the county.

Table 5 rates the soils in Smith County according to their suitability for elements of wildlife habitat and for general kinds of wildlife. Not considered in the ratings are present land use, existing vegetation, and the extent of artificial drainage provided, because these factors are subject to change. Also not considered is the ability of wildlife to move from place to place.

A rating of *good* means that the soil is relatively free of limitations or that the limitations are easily overcome. *Fair* means that the limitations need to be recognized, but that they can be overcome by good management and careful design. *Poor* means that limitations are severe enough to make use of the soil questionable for wildlife habitat. *Very poor* means that extreme measures are needed to overcome the limitations and that usage generally is not practical. A rating of "poor" or "very poor" does not necessarily mean that a soil cannot be managed for wildlife, but it does show that a high level of management is required to overcome the limitation.

The eight elements of wildlife habitat are defined in the following paragraphs.

Grain and seed crops.—Among these crops are corn, wheat, oats, barley, rye, grain sorghum, and millet.

Grasses and legumes.—These are planted grasses and legumes commonly used for forage. Examples are bromegrass, fescue, clover, alfalfa, and sudangrass.

Wild herbaceous upland plants.—In this group are native annuals, perennials, or other herbaceous plants that commonly grow in upland areas. Among them are dandelion, goldenrod, ragweed, sunflowers, lambsquarters, and native grasses.

Hardwood plants.—These plants are hardwood trees and shrubs that grow vigorously and produce sprouts, fruits, or seeds for wildlife food. These woody plants either grow naturally or are planted. Examples are oak, walnut, Russian-olive, hawthorn, plum, sumac, cotoneaster, cherries, and honeysuckle.

Coniferous plants.—Examples of native or planted coniferous trees and shrubs are pine, eastern redcedar, and Rocky Mountain juniper.

TABLE 5.—*Suitability of the soils for elements of wildlife habitat and kinds of wildlife*

[Absence of an entry indicates that the soil was not rated]

Soil series and map symbols	Elements of wildlife habitat								Kinds of wildlife			
	Grain and seed crops	Domestic grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Shrubs	Wetland plants	Shallow water areas	Openland	Woodland	Wetland	Rangeland
Alluvial land: Aa	Poor	Fair	Good	Good	Good	Good	Fair	Good	Fair	Good	Fair	
Armo: Ar	Fair	Good	Good	Good	Poor	Fair	Poor	Very poor	Good		Very poor	Fair.
Bogue: Bo	Poor	Fair	Poor	Poor	Poor	Poor	Very poor	Poor	Poor		Very poor	Poor.
Brownell: Br	Poor	Fair	Fair	Poor	Very poor	Fair	Very poor	Very poor	Fair		Very poor	Fair.
Campus: Cc. For Canlon part, see Canlon series.	Poor	Fair	Good	Poor	Poor	Fair	Very poor	Very poor	Fair		Very poor	Fair.
Canlon. Mapped only with Campus soils.	Very poor	Very poor	Poor	Very poor	Very poor	Fair	Very poor	Very poor	Poor		Very poor	Very poor.
Harney: Ha, Hb, Hc. For Mento part of Hc, see Mento series.	Fair	Good	Fair	Good	Poor	Fair	Very poor	Very poor	Fair		Very poor	Good.
Heizer: Hd. For Brownell part, see Brownell series.	Very poor	Very poor	Poor	Very poor	Very poor	Very poor	Very poor	Very poor	Poor		Very poor	Very poor.
Holdrege:												
He, Hf, Hg	Good	Good	Good	Fair	Poor	Fair	Very poor	Very poor	Good		Very poor	Good.
Holdrege part of Uh	Fair	Good	Good	Fair	Fair	Fair	Very poor	Very poor	Good		Very poor	Good.
Hord: Hh	Good	Good	Good	Good	Good	Good	Very poor	Very poor	Good		Very poor	Good.
Inavale: Im. For Munjor part, see Munjor series.	Fair	Fair	Good	Poor	Poor	Fair	Very poor	Very poor	Fair		Very poor	Good.
McCook: Ma, Mm. For Munjor part of Mm, see Munjor series.	Good	Good	Good	Good	Fair	Good	Very poor	Very poor	Good		Very poor	Good.
Mento. Mapped only with Harney series.	Fair	Good	Fair	Fair	Poor	Fair	Very poor	Very poor	Fair		Very poor	Fair.
Munjor. Mapped with McCook series.	Fair	Fair	Good	Good	Good	Good	Fair	Poor	Fair		Poor	Good.
Munjor. Mapped with Inavale series.	Fair	Good	Good	Good	Fair	Good	Poor	Very poor	Good		Very poor	Good.

New Cambria: Nc	Good	Good	Fair	Poor	Poor	Fair	Fair	Fair	Good		Fair	Fair.
Nuckolls: Nd, Nh. For Holdrege part of Nh, see Holdrege series.	Fair	Good	Good	Good	Good	Good	Very poor	Very poor	Good		Very poor	Good.
Penden: Pe	Fair	Good	Fair	Poor	Poor	Poor	Very poor	Very poor	Fair		Very poor	Fair.
Roxbury: Ro, Rr. For Armo part of Rr, see Armo series.	Good	Good	Good	Good	Fair	Fair	Poor	Very poor	Good		Very poor	Fair.
Rp	Fair	Fair	Fair	Fair	Fair	Fair	Very poor	Fair	Good		Poor	Fair.
Uly: Uh, Ur. For Holdrege part of Uh, see Holdrege series. For Roxbury part of Ur, see Roxbury, Rp.	Fair	Good	Good	Poor	Fair	Fair	Very poor	Very poor	Fair		Very poor	Good.
Wakeen: Wc, Wd	Fair	Good	Fair	Fair	Fair	Poor	Very poor	Very poor	Fair		Very poor	Fair.

Shrubs are bushy wood plants that produce fruits, buds, twigs, bark, or foliage used by wildlife or that provide cover and shade for some species of wildlife. Examples are mountainmahogany, bitterbrush, snowberry, and big sagebrush. Major soil properties that affect the growth of shrubs are depth of the root zone, available water capacity, salinity, and moisture.

Wetland food and cover plants.—These are plants that grow on moist or wet sites and that provide food and cover for waterfowl and furbearing animals. Examples are cattails, sedges, bulrushes, smartweed, pondweed, duckweed, and burreed.

Shallow-water developments.—These are impoundments of shallow water in marshy areas and stream channels. They consist of low dikes, nearly level ditches, dugouts, and devices to maintain water at a depth suitable for wetland wildlife.

Openland wildlife.—This kind of wildlife is made up of birds and mammals that normally frequent cropland, pasture, meadow, and areas overgrown with grasses, herbs, and shrubs. Examples are quail, pheasant, meadowlark, field sparrow, red fox, cottontail rabbit, prairie dog, and marsh hawk.

Woodland wildlife.—These birds and mammals normally frequent wooded areas consisting of hardwood trees, coniferous trees, shrubs, or mixed stands of such plants. Among them are squirrel, raccoon, woodpecker, warbler, brown thrush, deer, gray fox, and owl.

Wetland wildlife.—In this group are the birds and mammals that normally frequent such wet areas as ponds, marshes, and swamps. Examples are muskrat, beaver, duck, geese, heron, rail, kingfisher, mink, crane, and bittern.

Rangeland wildlife.—These are birds and mammals that prefer natural grasslands. Examples are jackrabbits, prairie dogs, meadowlarks, and mule deer.

Onsite technical assistance in planning developments for wildife and in determining suitable species of vegetation for planting can be obtained from the office of the Soil Conservation Service. Additional information and assistance can be obtained from the Bureau of Sport Fisheries and Wildlife; the Kansas Forestry, Fish, and Game Commission; and the Extension Service.

Recreation[6]

One historical point of interest in Smith County is the Geographic Center of the United States, which was determined by the Government geodetic survey in 1898. It is surrounded by Center Park, a public recreation area.

Knowledge of soils is necessary in planning, developing, and maintaining areas used for recreation. In table 6 the soils of Smith County are rated according to their suitability for campsites, playgrounds, picnic areas, and paths and trails.

In table 6 the soils are rated as having slight, moderate, or severe limitations for the specified uses. For all of these ratings, it is assumed that a good cover of vegetation can be established and maintained. A limita-

[6] ROBERT J. HIGGINS, biologist, Soil Conservation Service, Salina.

TABLE 6.—*Degree and kind of limitations of the soils for recreation facilities*

Soil series and map symbols	Campsites	Picnic areas	Playgrounds	Paths and trails
Alluvial land: Aa	Severe: flooding	Severe: flooding	Severe: flooding	Moderate: flooding.
Armo: Ar	Slight	Slight	Slight where slopes are less than 2 percent. Moderate where slopes are 2 to 6 percent. Severe where slopes are more than 6 percent.	Slight.
Bogue: Bo	Severe: clay texture; very slow permeability.	Severe: clay texture	Severe: clay texture; very slow permeability.	Severe: clay texture.
Brownell: Br	Moderate: gravelly loam texture; slopes of more than 8 percent in some places.	Moderate: gravelly loam texture; slopes of more than 8 percent in some places.	Severe where slopes are more than 6 percent.	Slight.
Campus: Cc For Canlon part, see Canlon series.	Slight	Slight	Moderate where slopes are 2 to 6 percent. Severe where slopes are more than 6 percent.	Slight.
Canlon Mapped only with Campus soils.	Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent.	Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent.	Severe where slopes are more than 6 percent; less than 20 inches to bedrock.	Moderate where slopes are 15 to 25 percent.
Harney: Ha, Hb, Hc For Mento part of Hc, see Mento series.	Moderate: moderately slow permeability.	Slight	Moderate where slopes are 2 to 6 percent.	Slight.
Heizer: Hd For Brownell part, see Brownell series.	Moderate	Moderate	Severe: gravelly loam texture; slopes of more than 6 percent in some places; less than 20 inches to bedrock.	Moderate: small stones.
Holdrege: He, Hf, Hg	Slight	Slight	Moderate where slopes are 2 to 6 percent.	Slight.
Holdrege part of Uh	Moderate where slopes are 8 to 15 percent.	Moderate where slopes are 8 to 15 percent.	Severe: slopes are more than 6 percent.	Slight.
Hord: Hh	Slight	Slight	Slight	Slight.
Inavale: Im For Munjor part, see Munjor series.	Moderate: loamy fine sand texture.	Moderate: loamy fine sand texture.	Moderate: loamy fine sand texture.	Moderate: loamy fine sand texture.
McCook: Ma	Slight	Slight	Slight	Slight.
McCook: Mm For Munjor part, see Munjor series.	Moderate to severe: flooding.	Moderate to severe: flooding.	Moderate to severe: flooding.	Slight.
Mento Mapped only with Harney soils.	Moderate: permeability	Slight	Moderate: slopes are 3 to 6 percent; permeability.	Slight.
Munjor Mapped with McCook soils.	Moderate to severe: flooding.	Moderate: flooding	Severe: flooding	Slight.
Munjor Mapped with Inavale soils.	Slight	Slight	Slight	Slight.
New Cambria: Nc	Moderate to severe: silty clay texture; flooding.	Moderate to severe: silty clay texture; flooding.	Moderate: silty clay texture; flooding.	Moderate: silty clay texture.
Nuckolls: Nd, Nh For Holdrege part of Nh, see Holdrege series.	Slight where slopes are 3 to 8 percent. Moderate where slopes are 8 to 15 percent.	Slight where slopes are 3 to 8 percent. Moderate where slopes are 8 to 15 percent.	Moderate where slopes are 2 to 6 percent. Severe where slopes are more than 6 percent.	Slight.

TABLE 6.—*Degree and kind of limitations of the soils for recreation facilities*—Continued

Soil series and map symbols	Campsites	Picnic areas	Playgrounds	Paths and trails
Penden: Pe	Slight	Slight	Moderate: slopes are 3 to 7 percent.	Slight.
Roxbury:				
Ro, Rr. For Armo part of Rr, see Armo series.	Slight	Slight	Slight	Slight.
Rp	Severe: flooding	Severe: flooding	Severe: flooding	Slight.
Uly: Uh, Ur. For Holdrege part, see Holdrege series. For Roxbury part, see Roxbury, Rp.	Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent.	Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent.	Severe where slopes are more than 6 percent.	Slight.
Wakeen: Wc	Slight	Slight	Moderate where slopes are 2 to 6 percent.	Slight.
Wakeen: Wd	Moderate where slopes are 8 to 15 percent.	Moderate where slopes are 8 to 15 percent.	Severe where slopes are more than 6 percent.	Slight.

tion of *slight* means that soil properties are generally favorable and limitations are so minor that they easily can be overcome. A *moderate* limitation can be overcome or modified by planning, by design, or by special maintenance. A *severe* limitation means that costly soil reclamation, special design, intense maintenance, or a combination of these is required.

Campsites are used intensively for tents, small camp trailers, and the accompanying activities of outdoor living. Little preparation of the site is required other than shaping and leveling for tent and parking areas. Camp areas are subject to heavy foot traffic and limited vehicular traffic. The best soils have mild slopes, good drainage, a surface free of rocks and coarse fragments, and are not subject to flooding during periods of heavy use; their surface is firm after rain but not dusty when dry.

Picnic areas are attractive natural or landscaped areas that carry heavy foot traffic. Most of the vehicular traffic, however, is confined to access roads. The best soils are firm when wet but not dusty when dry, are not subject to flooding during the season of use, and do not have slopes or stones that can greatly increase the cost of leveling or of building access roads.

Playgrounds are areas used intensively for baseball, football, badminton, and similar organized games. Soils suitable for this use need to withstand intensive foot traffic. The best soils have a nearly level surface free of coarse fragments and rock outcrops. They have good drainage and are not subject to flooding during periods of heavy use. Their surface is firm after rain but not dusty when dry. If grading and leveling are required, depth to rock is important.

Paths and trails are used for local and cross-country travel on foot or horseback. Design and layout should require little or no cutting and filling. The best soils are at least moderately well drained, are firm when wet but not dusty when dry, are flooded not more than once during the season of use, have slopes of less than 15 percent, and have few or no rocks or stones on the surface.

Engineering[7]

This section is useful to planning commissions, town and city managers, land developers, engineers, contractors, farmers, and others who need information about soils used as structural material or as foundation on which structures are built.

Among properties of soils highly important in engineering are permeability, strength, compaction characteristics, drainage, shrink-swell potential, grain size, plasticity, and reaction. Also important are depth to the water table, depth to bedrock, and slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this section of the soil survey can be helpful to those who:

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the soils on which they are built, to help predict performance of structures on the same or similar kinds of soil in other locations.
6. Predict the trafficability of soils for cross-

[7] CLIFTON E. DEAL and ARTHUR H. HOLSTE, civil engineers, Soil Conservation Service, helped prepare this section.

country movement of vehicles and construction equipment.

7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables. Table 7 shows estimated soil properties significant in engineering. Table 8 gives interpretations for various engineering uses. Table 9 evaluates the soils as sources of construction material. Table 10 shows the results of engineering laboratory tests on soil samples.

This information, along with the soil map and data in other parts of this publication, can be used to make interpretations in addition to those given in tables 7, 8, and 9, and it also can be used to make useful maps.

This information, however, does not eliminate the need for further investigation at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in the tables, generally depths of more than 6 feet. Also, inspection of sites, especially the small ones, is needed because many delineated areas

TABLE 7.—*Estimated soil properties*

[An asterisk in the first column indicates that this mapping unit is made up of two or more kinds of soil. The soils in such mapping table. The symbol > means more than; the

Soil series and map symbols	Depth to— Bedrock	Depth to— Seasonal water table	Depth from surface	USDA texture	Classification: Unified	Classification: AASHTO
	Ft	*Ft*	*In*			
Alluvial land: Aa. Properties too variable to be rated.						
Armo: Ar	>6	>6	0–12	Loam	CL, ML	A–6, A–4
			12–42	Heavy loam	CL, ML	A–6, A–4
			42–72	Loam	CL, ML	A–4, A–6
Bogue: Bo	2½	>6	0–25	Clay	CH	A–7–6
			25–72	Clay shale.		
Brownell: Br[1]	2½	>6	0–7	Gravelly loam	SM or SC	A–2–4, A–4–6
			7–16	Very gravelly loam	GM, GC	A–2–4, A–2–6
			16–30	Channery loam	GM, GC	A–2–4, A–2–6
			30	Soft limestone.		
*Campus: Cc. For Canlon part of Cc, see Canlon series.	2½	>6	0–18	Loam	ML, CL	A–6, A–7–6
			18–32	Light loam	CL	A–6, A–7–6
			32–72	Soft caliche.		
Canlon. Mapped only with Campus soils.	1¼	>6	0–6	Loam	ML, CL	A–4, A–6
			6–14	Light gravelly loam	SC	A–2, A–4
			14	Hard caliche.		
*Harney: Ha, Hb, Hc. For Mento part of Hc, see Mento series.	>6	>10	0–8	Silt loam	ML, CL	A–4, A–6
			8–42	Silty clay loam	CL, CH	A–6, A–7–6
			42–72	Silt loam	ML, CL	A–4, A–6
*Heizer: Hd. For Brownell part of Hd, see Brownell series.	1¼	>6	0–8	Gravelly loam	SM, SC	A–2–4, A–2–6
			8–14	Channery loam	GM, GC	A–2–4, A–2–6
			14	Soft limestone.		
Holdrege: He, Hf, Hg	>6	>10	0–10	Silt loam	ML, CL	A–4, A–6
			10–28	Silty clay loam	CL, CH	A–7, A–6
			28–72	Silt loam	CL, ML	A–4, A–6
Hord: Hh	>6	>6	0–32	Silt loam	CL	A–4, A–6
			32–72	Silt loam	CL	A–6, A–7–6
*Inavale: Im. For Munjor part of Im, see Munjor series.	>6	>5	0–18	Loamy fine sand	SM	A–2–4
			18–72	Fine sand	SP–SM, SM	A–3, A–2–4

of a given soil can include small areas of other kinds of soil that have strongly contrasting properties and different suitability or limitations for soil engineering.

Some of the terms used in this survey have special meaning to soil scientists. The Glossary defines many of the terms commonly used in soil science.

Engineering soil classification systems

The two systems most commonly used in classifying samples of soils for engineering are the Unified system (*2*) used by SCS engineers, the Department of Defense, and others, and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO) (*1*).

In the Unified system, soils are classified according to particle-size distribution, plasticity, liquid limit, and organic matter. Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between

significant in engineering

units have different properties, and for this reason it is necessary to refer to other series as indicated in the first column of this symbol < means less than]

Percentage smaller than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
						In per in	*In per in of soil*	*pH*			
95–100	95–100	90–95	70–90	30–40	12–20	0.6–2.0	0.20–0.22	7.4–7.8	Low	Low	Low.
95–100	95–100	90–95	70–90	30–40	12–20	0.6–2.0	0.17–0.19	7.9–8.4	Low	Low	Low.
60–80	50–60	50–60	50–60	25–35	7–15	0.6–2.0	0.12–0.14	7.9–8.4	Low	Low	Low.
	100	90–100	90–100	55–75	35–50	<0.06	0.11–0.13	6.1–8.4	High	High	High.
50–80	40–50	30–45	20–35	20–40	7–20	0.6–2.0	0.16–0.18	7.9–8.4	Low	Low	Low.
40–50	30–45	20–40	13–30	20–40	7–20	2.0–6.0	0.12–0.14	7.9–8.4	Low	Low	Low.
20–40	15–35	10–30	8–25	20–40	7–20	2.0–6.0	0.09–0.11	7.9–9.0	Low	Low	Low.
90–100	90–100	75–95	50–80	35–45	11–20	0.6–2.0	0.20–0.22	7.4–7.8	Low	Medium	Low.
90–100	85–100	65–85	50–80	35–45	15–20	0.6–2.0	0.17–0.19	7.9–8.4	Low	Medium	Low.
90–100	85–100	85–100	65–85	25–40	8–20	0.6–2.0	0.20–0.22	7.4–8.4	Low	Low	Low.
60–80	50–75	40–60	25–50	20–35	7–15	0.6–2.0	0.15–0.17	7.4–8.4	Low	Low	Low.
		100	95–100	28–40	6–15	0.6–2.0	0.22–0.24	6.1–6.5	Low to moderate.	High	Low.
		100	95–100	35–55	15–30	0.2–0.6	0.18–0.20	6.1–8.4	Moderate to high.	High	Low.
		100	95–100	28–40	10–20	0.6–2.0	0.20–0.22	7.9–8.4	Low	High	Low.
50–80	40–50	30–45	20–35	20–40	7–20	0.6–2.0	0.16–0.18	7.9–8.4	Low	Low	Low.
20–40	15–35	10–30	8–25	20–40	7–20	2.0–6.0	0.09–0.11	7.9–8.4	Low	Low	Low.
	100	98–100	95–100	24–40	2–14	0.6–2.0	0.22–0.24	6.1–6.5	Low	Low	Low.
	100	98–100	95–100	30–55	20–35	0.6–2.0	0.18–0.20	6.1–7.3	Low to moderate.	Low	Low.
	100	98–100	95–100	30–45	5–20	0.6–2.0	0.20–0.22	7.4–8.4	Low to moderate.	Low	Low.
		100	90–100	30–48	8–30	0.6–2.0	0.22–0.24	6.1–7.3	Low to moderate.	Low	Low.
	100	95–100	90–100	30–48	8–30	0.6–2.0	0.17–0.19	7.4–8.4	Low to moderate.	Low	Low.
	100	85–95	15–35	[2]NP	[2]NP	6.0–20.0	0.10–0.12	7.4–7.8	Very low	Low	Low.
	100	70–90	5–30	NP	NP	>20.0	0.06–0.08	7.4–7.8	Very low	Low	Low.

TABLE 7.—*Estimated soil properties*

Soil series and map symbols	Depth to— Bedrock	Depth to— Seasonal water table	Depth from surface	USDA texture	Classification Unified	Classification AASHTO
	Ft	*Ft*	*In*			
*McCook: Ma, Mm. For Munjor part of Mm, see Munjor series.	>6	>10	0–72	Coarse silt loam	ML, CL	A-4, A-6
Mento. Mapped only with Harney soils.	5	>5	0–8	Silt loam	ML, CL	A-4, A-6
			8–18	Heavy silty clay loam	CH	A-7-6
			18–64	Light silty clay loam	CL, CH	A-7-6
			64	Soft limestone.		
Munjor. Mapped only with Inavale and McCook soils.	5	5	0–38	Fine sandy loam	SM-SC, SM	A-2-4
			38–72	Fine sand	SP, SM	A-3
New Cambria: Nc	>6	>6	0–72	Silty clay	CH, CL	A-7-6
*Nuckolls: Nd, Nh. For Holdrege part of Nh, see Holdrege series.	>6	>10	0–10	Silt loam	ML, CL	A-4, A-6
			10–20	Light silty clay loam	CL	A-6, A-7-6
			20–72	Silt loam	CL, ML	A-4, A-6
Penden: Pe	>6	>10	0–10	Loam	CL	A-6
			10–72	Clay loam	CL	A-6, A-7-6
*Roxbury: Ro, Rp, Rr. For Armo part of Rr, see Armo series.	>6	>6	0–72	Silt loam, silty clay loam	CL, ML	A-4, A-6
*Uly: Uh, Ur. For Holdrege part of Uh, and Roxbury part of Ur, see Holdrege and Roxbury series.	>6	>10	0–72	Silt loam	ML, CL	A-4, A-6
Wakeen: Wc, Wd	3	>6	0–9	Silt loam	CL	A-6
			9–34	Silty clay loam	CL	A-6, A-7
			34	Soft chalky shale.		

[1] Coarse fragments larger than 3 inches in diameter make up 5 to 30 percent of the 0 to 16 inch layer and 10 to 40 percent of the 16 to 30 inch layer.

two classes are designated by symbols for both classes, for example, CL-ML.

The AASHTO system is used to classify soils according to those properties that affect use in highway construction and maintenance. In this system, a soil is placed in one of seven basic groups ranging from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A-1 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A-7, are clay soils that have low strength when wet and that are the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A-1, A-2, and A-7 groups are divided as follows: A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, and A-7-6. The AASHTO classification for tested soils is shown in table 10; the estimated classification is given in table 7 for all soils mapped in the survey area.

Soil properties significant in engineering

Several estimated soil properties significant in engineering are given in table 7. These estimates are made for typical soil profiles, by layers sufficiently different to have different significance for soil engineering. The estimates are based on field observations made in the course of mapping, on test data for these and similar soils, and on experience with the same kinds of soil in other counties. Following are explanations of some of the column headings in table 7.

Depth to bedrock is distance from the surface of the soil to the rock layer.

Depth to seasonal high water table is distance from the surface of the soil to the highest level that ground water reaches in the soil in most years.

Soil texture is described in table 7 in the standard terms used by the Department of Agriculture. These terms take into account relative percentages of sand,

significant in engineering—Continued

Percentage smaller than 3 inches passing sieve— No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)	Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity: Uncoated steel	Corrosivity: Concrete
						In per in	*In per in of soil*	*pH*			
....	100	90–100	70–100	25–35	4–7	0.6–2.0	0.17–0.19	7.4–8.4	Low	Low	Low.
....	100	90–100	85–100	30–40	8–15	0.6–2.0	0.22–0.24	6.6–7.3	Low to moderate.	Low	Low.
100	95–100	90–100	85–100	55–70	40–50	0.06–0.2	0.18–0.20	7.4–7.8	High	High	Moderate.
100	95–100	90–100	85–100	41–65	20–45	0.2–0.6	0.18–0.20	7.9–8.4	Moderate	High	Moderate.
100	95–100	60–70	20–35	20–35	3–7	2.0–6.0	0.13–0.15	7.4–8.4	Low	Low	Low.
95–100	90–95	55–70	0–10	NP	NP	6.0–20.0	0.06–0.08	7.9–8.4	Low	Low	Low.
....	100	95–100	90–100	41–60	30–45	0.06–0.2	0.12–0.14	7.4–8.4	High	High	Low.
....	100	95–100	90–100	24–40	2–14	0.6–2.0	0.22–0.24	6.1–6.5	Low	Low	Low.
....	100	95–100	85–98	28–48	20–35	0.6–2.0	0.18–0.20	6.6–7.3	Low to moderate.	Low	Low.
....	100	95–100	85–95	28–45	5–18	0.6–2.0	0.20–0.22	6.6–7.8	Low	Low	Low.
....	100	90–100	70–85	30–40	10–22	0.6–2.0	0.20–0.22	7.4–8.4	Moderate	Low	Low.
....	100	90–100	80–95	30–50	15–25	0.6–2.0	0.15–0.19	7.4–8.4	Low to moderate.	Moderate	Low.
....	100	96–100	65–95	25–40	2–20	0.6–2.0	0.20–0.22	7.4–8.4	Low	Low	Low.
....	....	100	90–100	30–45	7–18	0.6–2.0	0.20–0.22	6.1–7.8	Moderate	Low	Low.
....	100	90–100	85–95	30–40	15–25	0.6–2.0	0.22–0.24	7.4–8.4	Low	Low	Low.
....	100	95–100	80–95	30–50	11–25	0.6–2.0	0.18–0.20	7.4–8.4	Low to moderate.	Low	Low.

[2] NP means nonplastic.

silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, for example, "gravelly loamy sand." "Sand," "silt," "clay," and some of the other terms used are defined in the Glossary of this soil survey.

Liquid limit and plasticity index indicate the effect of water on the strength and consistency of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from semisolid to plastic. If the moisture content is further increased, the material changes from plastic to liquid. The plastic limit is the moisture content at which the soil material changes from semisolid to plastic; and the liquid limit, from plastic to liquid. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of mosture content within which a soil material is plastic. Liquid limit and plasticity index are estimated in table 7, but in table 10 the data on liquid limit and plasticity index are based on tests of soil samples.

Permeability is that quality of a soil that enables it to transmit water or air. It is estimated on the basis of those soil characteristics observed in the field, particularly structure and texture. The estimates in table 7 do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

Available water capacity is the ability of soils to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most crop plants.

Reaction is the degree of acidity or alkalinity of a soil, expressed in pH values. The pH value and terms used to describe soil reaction are explained in the Glossary.

TABLE 8.—*Interpretations of*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The indicated in the

Soil series and map symbols	Degree and kind of limitations for—				
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings	Roads and streets
Alluvial land: Aa. No interpretations.					
Armo: Ar	Slight	Moderate: moderate permeability.	Slight	Slight	Moderate: low strength.
Bogue: Bo	Severe: very slow permeability.	Moderate to severe: 3 to 15 percent slopes; shale at a depth of less than 40 inches.	Severe: shale at a depth of less than 40 inches; clayey.	Severe: high shrink-swell potential; slope.	Severe: high shrink-swell potential; slope; poor workability.
Brownell: Br	Severe: bedrock at a depth of 20 to 40 inches.	Severe: bedrock at a depth of 20 to 40 inches.	Severe: bedrock at a depth of 20 to 40 inches.	Severe for dwellings with basements: bedrock at a depth of 20 to 40 inches. Moderate for dwellings without basements.	Moderate: bedrock at depth of 20 to 40 inches; 3 to 15 percent slopes.
*Campus: Cc. For Canlon part, see Canlon series.	Severe: caliche bedrock at a depth of 20 to 40 inches.	Severe: caliche bedrock at a depth of 20 to 40 inches.	Moderate: caliche bedrock at a depth of 20 to 40 inches.	Moderate: bedrock at a depth of 20 to 40 inches. For dwellings without basements: slope is also a factor.	Moderate: caliche bedrock at a depth of 20 to 40 inches; 5 to 12 percent slopes.
Canlon. Mapped only with Campus soils.	Severe: caliche bedrock at a depth of 10 to 20 inches.	Severe: caliche bedrock at a depth of 10 to 20 inches; slope.	Severe: bedrock at a depth of 10 to 20 inches.	Severe: depth to bedrock.	Severe: bedrock at a depth of less than 20 inches; 5 to 30 percent slopes.
*Harney: Ha, Hb, Hc. For Mento part of Hc, see Mento series.	Severe: moderately slow permeability.	Slight if slopes of less than 2 percent. Moderate if 2 to 7 percent slopes.	Slight	Moderate to severe: moderate to high shrink-swell potential.	Moderate to severe: moderate to high shrink-swell potential.
*Heizer: Hd. For Brownell part, see Brownell series.	Severe: bedrock at a depth of 10 to 20 inches; 5 to 30 percent slopes.	Severe: bedrock at a depth of 10 to 20 inches; 5 to 30 percent slopes.	Severe: bedrock at a depth of 10 to 20 inches.	Severe: bedrock at a depth of 10 to 20 inches; 5 to 30 percent slopes.	Severe: bedrock at a depth of less than 20 inches; 7 to 30 percent slopes.
Holdrege: He, Hf, Hg	Slight to moderate: moderate permeability.	Moderate: moderate permeability; slope.	Slight if 0 to 8 percent slopes. Moderate if 8 to 12 percent slopes.	Moderate: low to moderate shrink-swell potential.	Moderate: low to moderate shrink-swell potential.
Hord: Hh	Slight to moderate: moderate permeability.	Moderate: moderate permeability.	Slight	Slight to moderate: low to moderate shrink-swell potential.	Moderate: low strength.

engineering properties of the soils

soils in such mapping units have different properties and limitations, and for this reason it is necessary to refer to other series as first column of this table]

Degree and kind of limitations for—Cont.		Soil features affecting—				
Sanitary landfill (trench)	Sanitary landfill (area)	Highway location[1]	Pond reservoir areas	Embankments, dikes and levees	Terraces, diversions, and waterways	Irrigation
Severe: seepage	Slight	Slopes of 2 to 7 percent; moderate erodibility.	High seepage losses.	Fair to good stability and compaction characteristics; medium compressibility; low shrink-swell potential.	Pockets of limestone gravel in places.	Slope; pockets of limestone gravel in places.
Severe: shale at a depth of 20 to 40 inches; clayey.	Moderate: slope.	Shale at a depth of less than 40 inches; 3 to 15 percent slopes; poor workability; difficult to revegetate.	Very slow permeability; shale at a depth of less than 40 inches.	High shrink-swell potential; poor shear strength; fair to poor stability.	Very slow permeability; clayey; slope; shale at a depth of less than 40 inches.	Very slow permeability; slope.
Severe: bedrock at a depth of 20 to 40 inches.	Moderate: 3 to 15 percent slope.	Slopes of 3 to 15 percent; bedrock at a depth of less than 40 inches.	Bedrock at a depth of 20 to 40 inches; seepage potential.	Limited borrow material; fair to good shear strength; good to fair stability; good compaction characteristics.	Severe: bedrock at a depth of 20 to 40 inches.	Low available water capacity; bedrock at a depth of 20 to 40 inches.
Severe: bedrock at a depth of 20 to 40 inches.	Moderate: 5 to 12 percent slopes.	High erodibility; 5 to 12 percent slopes; caliche bedrock at a depth of 20 to 40 inches.	Caliche bedrock at a depth of 20 to 40 inches; low shrink-swell potential.	Limited borrow material; fair stability and compaction characteristics.	Caliche bedrock at a depth of 20 to 40 inches; slope.	Moderate available water capacity; caliche bedrock at a depth of 20 to 40 inches.
Severe: bedrock at a depth of 10 to 20 inches; slope.	Moderate: 8 to 15 percent slopes. Severe: more than 15 percent slope.	Caliche bedrock at a depth of 10 to 20 inches; high erodibility; 5 to 30 percent slopes.	Bedrock at a depth of 10 to 20 inches; seepage in places.	Shallow soil erodibility.	Shallow soil over caliche.	Not applicable.
Moderate: medium soil texture.	Slight: slopes of less than 8 percent.	No detrimental features.	Moderately slow permeability.	Moderate to high shrink-swell potential; fair to poor compaction characteristics.	Clayey subsoil; 0 to 7 percent slopes.	Moderately slow permeability; 0 to 7 percent slopes.
Severe: bedrock at a depth of 10 to 20 inches.	Moderate if 5 to 15 percent slopes. Severe if 15 to 30 percent slopes.	Bedrock at a depth of 10 to 20 inches; 7 to 30 percent slopes.	Severe: seepage potential; bedrock at a depth of 10 to 20 inches; 5 to 30 percent slopes.	Thin surface layer	Shallow soil; bedrock at a depth of 10 to 20 inches.	Not applicable.
Slight	Slight if 0 to 8 percent slopes. Moderate if slopes of more than 8 percent.	Erodible: 0 to 12 percent slopes.	Moderate permeability; low to moderate seepage potential.	Fair compaction characteristics; fair shear strength.	Moderate permeability.	High available water capacity; medium intake rate; slope.
Slight	Slight	No detrimental features.	Low to moderate seepage potential.	Good compaction characteristics.	Favorable	High available water capacity; medium intake rate; nearly level.

TABLE 8.—*Interpretations of*

Soil series and map symbols	Degree and kind of limitations for—				
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings	Roads and streets
*Inavale: Im. For Munjor part, see Munjor series.	Moderate: flooding rare; fluctuating water table; rapid permeability.	Severe: rapid permeability.	Severe: poor sidewall stability.	Severe: subject to flooding.	Moderate: subject to flooding.
*McCook: Ma, Mm. For Munjor part of Mm, see Munjor series.	Slight if protected from flooding. Severe if subject to flooding.	Moderate if protected from flooding; moderate permeability. Severe if subject to flooding.	Slight if protected from flooding. Severe if subject to flooding.	Slight if protected from flooding. Severe if subject to flooding.	Slight if protected from flooding. Severe if subject to flooding.
Mento. Mapped only with Harney soils.	Severe: slow permeability; bedrock at a depth of 40 to 72 inches.	Moderate: 3 to 7 percent slopes; bedrock at a of 40 to 72 inches.	Slight.	Severe: high shrink-swell potential.	Severe: high shrink-swell potential.
Munjor. Mapped only with Inavale and McCook soils.	Severe: subject to flooding; moderately rapid permeability; fluctuating water table.	Severe: subject to flooding; moderately rapid permeability.	Severe: flooding hazard.	Severe: subject to flooding.	Moderate to severe: subject to flooding.
New Cambria: Nc.	Severe: slow permeability.	Slight: flood protection needed in places.	Severe: silty clay.	Severe: high shrink-swell potential.	Severe: high shrink-swell potential; poor workability.
*Nuckolls: Nd, Nh. For Holdrege part of Nh, see Holdrege series.	Slight if slopes of less than 8 percent. Moderate if 8 to 12 percent slopes.	Moderate if slopes of less than 7 percent. Severe if slope of more than 7 percent; moderate permeability.	Slight if slopes of less than 8 percent. Moderate if 8 to 12 percent slopes.	Moderate: 3 to 12 percent slopes; low to moderate shrink-swell potential.	Moderate: 3 to 12 percent slopes; low to moderate shrink-swell potential.
Penden: Pe.	Moderate: moderate permeability.	Moderate: 3 to 7 percent slopes; moderate permeability.	Moderate: clay loam.	Moderate: moderate shrink-swell potential.	Moderate: moderate shrink-swell potential.
*Roxbury:					
Ro, Rr. For Armo part of Rr, see Armo series.	Slight if protected from flooding. Severe if subject to flooding.	Moderate if protected from flooding; moderate permeability. Severe if subject to flooding.	Slight if protected from flooding. Severe if subject to flooding.	Slight if protected from flooding. Severe if subject to flooding.	Slight if protected from flooding. Severe if subject to flooding.
Rp.	Severe: frequent flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: flooding hazard.	Severe: subject to flooding.
*Uly: Uh, Ur. For Holdrege part of Uh and Roxbury part of Ur, see Holdrege series and Rp in Roxbury series.	Moderate if 7 to 15 percent slopes. Severe if slopes of more than 15 percent.	Severe if slopes of more than 7 percent; moderate permeability.	Moderate if 7 to 15 percent slopes. Severe if slopes of more than 15 percent.	Moderate if 7 to 15 percent slopes. Severe if slopes of more than 15 percent.	Moderate if slopes of less than 15 percent. Severe if slopes of more than 15 percent.
Wakeen: Wc, Wd.	Severe: chalky shale at a depth of 20 to 40 inches.	Severe: chalky shale at a depth of 20 to 40 inches.	Moderate if slopes of less than 15 percent: rippable bedrock at a depth of 20 to 40 inches. Severe if slopes of more than 15 percent.	Moderate if slopes of less than 15 percent: rippable bedrock at a depth of 20 to 40 inches. Severe if slopes of more than 15 percent.	Moderate if 3 to 15 percent slopes: moderate shrink-swell potential. Severe if slopes of more than 15 percent.

[1] G. N. CLARK, Soil Engineer, and HERBERT E. WORLEY, Soils Research Engineer, Kansas State Highway Commission, assisted in preparing the information in this column.

engineering properties of the soils—Continued

Degree and kind of limitations for—Cont.		Soil features affecting—				
Sanitary landfill (trench)	Sanitary landfill (area)	Highway location[1]	Pond reservoir areas	Embankments, dikes and levees	Terraces, diversions, and waterways	Irrigation
Severe: subject to flooding; rapid permeability.	Severe: rapid permeability.	Subject to flooding; high erodibility.	High seepage losses.	High erodibility.	Too sandy.	Low available water capacity; severe soil blowing hazard.
Slight if protected from flooding. Severe if subject to flooding.	Slight if protected from flooding. Severe if subject to flooding.	High erodibility; subject to flooding in places.	Moderate permeability; high seepage losses.	Moderate erodibility.	Nearly level; subject to flooding in places.	Nearly level; subject to flooding in places.
Severe: bedrock at a depth of 40 to 72 inches; soil texture.	Slight.	Slopes of 3 to 7 percent; bedrock at a depth of 40 to 72 inches.	Slow permeability; bedrock at a depth of 40 to 72 inches.	High shrink-swell potential; fair to poor compaction characteristics.	Clayey subsoil; 3 to 7 percent slopes.	Slow permeability; 3 to 7 percent slopes.
Severe: subject to flooding; moderately rapid permeability.	Severe: subject to flooding; rapid permeability.	Subject to flooding; nearly level; high erodibility.	Moderately rapid permeability.	Pervious material; good shear strength.	Not applicable.	High intake rate; moderate available water capacity.
Severe: silty clay; possible flooding.	Moderate: local flooding in places.	Slow permeability; poor workability.	Slopes of 0 to 2 percent; slow permeability.	High shrink-swell potential; poor shear strength.	Clayey soil; nearly level.	Slow permeability; slow release of water.
Slight.	Slight if 3 to 8 percent slopes. Moderate if 8 to 12 percent slopes.	Erodible; 3 to 12 percent slopes.	Moderate permeability; low to moderate seepage potential.	Slopes erodible; fair compaction characteristics; fair stability.	Susceptible to erosion; moderate permeability; 3 to 12 percent slopes.	Erodible on slopes; high available water capacity; deep soil; sloping.
Moderate: clay loam.	Slight.	Erodible; 3 to 7 percent slopes.	Moderate permeability.	Moderate shrink-swell potential; fair to good stability and compaction characteristics.	Slope; erodible layers; high in calcium carbonate.	Slope.
Slight if protected from flooding. Severe if subject to flooding.	Slight if protected from flooding. Severe if subject to flooding.	No detrimental features.	Moderate permeability.	Good shear strength.	Moderate permeability; nearly level.	Deep soil; high available water capacity; moderate permeability.
Severe: subject to flooding.	Severe: subject to flooding.	Subject to flooding.	Moderate permeability; subject to flooding.	Fair compaction; medium to low shear strength.	Moderate permeability; subject to flooding.	Subject to flooding.
Slight if 0 to 15 percent slopes. Moderate if 15 to 30 percent slopes.	Moderate if 7 to 15 percent slopes. Severe if 15 to 30 percent slopes.	Erodible; 7 to 30 percent slopes.	Moderate seepage; fair to poor bank stability.	Fair bank stability and compaction characteristics.	Erosion hazard severe on steep slopes; highly erodible if subsoil is exposed.	Erosion hazard severe on steep slopes.
Moderate: soil texture; rippable bedrock at a depth of 20 to 40 inches.	Slight if 3 to 8 percent slopes. Moderate if 8 to 15 percent slopes. Severe if slopes of more than 15 percent.	Slopes of 3 to 20 percent; rippable bedrock at a depth of 20 to 40 inches; difficult to revegetate.	Moderate permeability; bedrock at a depth of 20 to 40 inches; 3 to 20 percent slopes.	Fair stability; good compaction characteristics; fair shear strength; moderate erodibility.	Moderate permeability; 3 to 30 percent slopes; bedrock at a depth of 20 to 40 inches; calcareous.	Moderate permeability; moderate available water capacity; bedrock at a depth of 20 to 40 inches.

TABLE 9.—*Suitability of the soils as a source of construction material*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in such mapping units may have different properties and limitations, and for this reason it is necessary to refer to other series as indicated in the first column of this table]

Soil series and map symbols	Sanitary landfill cover material	Topsoil	Sand and gravel	Road subgrade[1]	Road fill[1]
Alluvial land: Aa. Soil material too variable to be rated.					
Armo: Ar	Good	Fair for surface layer	Unsuited but pockets of limestone gravel in substratum.	Fair: medium soil support.	Fair: fair shear strength.
Bogue: Bo	Poor: clayey	Poor: very firm consistence; clayey.	Unsuited	Poor: low soil support; high plasticity.	Poor: poor shear strength.
Brownell: Br	Fair: gravelly loam	Poor: gravelly loam	Sand: unsuited. Gravel: fair source of road surface material.	Good for upper 16 inches. Poor below 16 inches: 3- to 6-inch rock fragments.	Good.
*Campus: Cc. For Canlon part, see Canlon series.	Poor: difficult to reclaim area.	Poor: surface layer is 8 inches thick; difficult to reclaim area.	Unsuited	Fair: medium soil support.	Fair: fair shear strength.
Canlon. Mapped only with Campus soils.	Poor: less than 20 inches of material.	Poor: limited depth of suitable material.	Poor except for local sand pockets.	Poor: low soil support	Fair: fair shear strength.
*Harney: Ha, Hb, Hc. For Mento part of Hc, see Mento series.	Fair: too clayey	Fair: clayey below a depth of 8 inches.	Unsuited	Fair: medium soil support.	Fair: fair shear strength.
*Heizer: Hd. For Brownell part, see Brownell series.	Poor: less than 20 inches of material.	Poor: less than 8 inches	Poor for gravel	Poor: 3- to 8-inch rock fragments.	Fair: fair workability; erodible.
Holdrege: He, Hf, Hg	Good if 0 to 8 percent slopes. Fair if slopes more than 8 percent.	Fair: clayey below a depth of 14 inches.	Unsuitable	Fair: medium soil support.	Good.
Hord: Hh	Good	Good	Unsuitable	Fair: medium soil support.	Good.
*Inavale: Im. For Munjor part, see Munjor series.	Poor: too sandy	Poor: too sandy; low organic matter content.	Sand: fair. Gravel: unsuited.	Good if confined	Good.
*McCook: Ma, Mm. For Munjor part of Mm, see Munjor series.	Good	Good	Unsuited	Good	Good.
Mento. Mapped only with Harney soils.	Fair: too clayey	Fair: clayey below a depth of 8 inches.	Unsuited	Fair: medium soil support.	Fair: fair shear strength.
Munjor. Mapped only with Inavale and McCook soils.	Good	Good: sandy loam and loam.	Sand: poor; poorly graded in substratum. Gravel: unsuitable.	Good if confined	Good.
New Cambria: Nc	Poor: silty clay	Poor: firm consistence; silty clay.	Unsuited	Poor: high plasticity; low soil support.	Poor: poor shear strength.
*Nuckolls: Nd, Nh. For Holdrege part of Nh, see Holdrege series.	Good	Good	Unsuitable	Fair: medium soil support.	Good.

Penden: Pe	Fair: clay loam	Fair: surface layer 10 inches thick.	Unsuitable: sand in substratum in places.	Fair: medium soil support.	Good.
*Roxbury:					
Ro, Rr. For Armo part of Rr, see Armo series.	Good	Good	Unsuited	Fair: medium soil support.	Fair: fair shear strength.
Rp	Good	Good	Unsuited	Fair: medium soil support.	Fair: fair shear strength.
*Uly: Uh, Ur. For Holdrege part of Uh, and Roxbury part of Ur, see Holdrege series and Rp in Roxbury series.	Good	Good quality if not eroded. Fair if eroded due to low fertility.	Unsuited	Fair: medium soil support.	Good.
Wakeen: Wc, Wd	Fair	Fair: silt loam surface layer.	Unsuited	Poor: low soil support.	Fair: fair shear strength.

[1] G. N. CLARK, Soils Engineer, and HERBERT E. WORLEY, Soils Research Engineer, Kansas State Highway Commission, assisted in preparing the information in these columns.

Shrink-swell potential is the relative change in volume of soil material to be expected with changes in moisture content, that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. The shrinking and swelling of soils causes much damage to building foundations, roads, and other structures. A *high* shrink-swell potential indicates a hazard to the maintenance of structures built in, on, or with material having this rating.

Corrosivity pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. Rate of corrosion of uncoated steel is related to soil properties such as drainage, texture, total acidity, and electrical conductivity of the soil material. Corrosivity for concrete is influenced mainly by the content of sodium or magnesium sulfate, but also by soil texture and acidity. Installations of uncoated steel that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations entirely in one kind of soil or in one soil horizon. A corrosivity rating of *low* means that there is a low probability of soil-induced corrosion damage. A rating of *high* means that there is a high probability of damage, so that protective measures for steel and more resistant concrete should be used to avoid or minimize damage.

Engineering interpretations of the soils

The estimated interpretations in tables 8 and 9 are based on the engineering properties of soils shown in table 7, on test data for soils in this survey area and others nearby or adjoining, and on the experience of engineers and soil scientists with the soils of Smith County.

In table 8, ratings are used to summarize limitations of the soils for all listed purposes other than for highway location, pond reservoir areas, embankments, dikes, and levees, terraces, diversions and waterways, and irrigation. For these particular uses, table 8 lists those soil features not to be overlooked in planning, installation, and maintenance.

Soil limitations are indicated by the ratings slight, moderate, and severe. *Slight* means soil properties generally are favorable for the rated use, or in other words, the limitations are minor and easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* means soil properties are so unfavorable and so difficult to correct or overcome that major soil reclamation and special designs are required.

Following are explanations of some of the columns in table 8.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material from a depth of 18 inches to 6 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that effect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope affects layout and construction and

TABLE 10.—*Engineering*

[Tests performed by the State Highway Commission of Kansas according to standard procedures of the

Soil name and location	Parent material	Report No. S72Kans-	Depth	Moisture-density data[1]	
				Maximum dry density	Optimum moisture
			Inches	*Pounds per cubic foot*	*Percent*
Harney silt loam:					
2 miles south and 6 miles east of Smith Center; 1,200 feet west and 325 feet north of the southeast corner of section 33, T. 3 S., R. 12 W. (Modal)	Loess	92-2-1	0-8	98	20
		92-2-2	16-22	98	21
		92-2-3	28-42	99	21
		92-2-4	42-72	100	20
Holdrege silt loam:					
10 miles north and 2 miles west of Athol; 1,700 feet west and 525 feet south of the northeast corner of section 36, T. 1 S., R. 15 W. (Modal)	Loess	92-3-1	0-10	95	19
		92-3-2	14-20	95	22
		92-3-3	28-72	103	19
Hord silt loam:					
8 miles north and 1 mile west of Kensington; 1,200 feet east and 750 feet north of the southwest corner of section 7, T. 2 S., R. 15 W. (Modal)	Silty alluvium	92-4-1	0-15	100	19
		92-4-2	15-32	98	20
		92-4-3	32-42	100	20
		92-4-4	42-72	96	22
McCook silt loam:					
1 mile west of Gaylord; 500 feet west and 300 feet south of the northeast corner of section 2, T. 5 S., R. 14 W.	Coarse silty alluvium	92-1-1	0-10	104	17
		92-1-2	18-40	105	16

[1] Based on AASHTO designation T99-61, method A (*1*) with the following variations: (1) all material is ovendried at 230° F; (2) all material is crushed in a laboratory crusher after drying; and (3) no time is allowed for dispersion of moisture after mixing with the soil material.

[2] Mechanical analyses based on AASHTO designation T88-57 (*1*) with the following variations: (1) all material is ovendried at 230° F and crushed in a laboratory crusher; (2) the sample is not soaked prior to dispersion; (3) sodium silicate is used as the dispersing agent; and (4) dispersing time, in minutes, is established by dividing the plasticity index value by 2; the maximum time is 15 minutes, and the minimum time is 1 minute. Results by this procedure frequently may differ somewhat from results that

also the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage, within a depth of 2 to 5 feet, long enough for bacteria to decompose the solids. A lagoon has a nearly level floor; its sides, or embankments, are of soil material compacted to medium density, and the pond is protected from flooding. Properties that affect the pond floor are permeability, organic matter, and slope; if the floor needs to be leveled, depth to bedrock becomes important. The soil properties that affect the embankment are those that influence the ease of excavation and compaction of the embankment material—the engineering properties of the embankment material as interpreted from the Unified Soil Classification and the amount of stones, if any.

Shallow excavations are those that require digging or trenching to a depth of less than 6 feet, for example, excavations for pipelines, sewer lines, phone and power transmission lines, basements, open ditches, and cemeteries. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, absence of rock outcrops or big stones, and freedom from flooding or absence of a high water table.

Dwellings, as rated in table 8, are not more than three stories high and are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for dwellings are those that relate to capacity to support load and resist settlement under load, and those that relate to ease of excavation. Soil properties that affect capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Roads and streets, as rated in table 8, have an all-weather surface expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. These roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep.

Soil properties that most affect design and construction of roads and streets are load-supporting capacity, stability of the subgrade, and the workability and quantity of cut and fill material available. The AASHTO and Unified classifications of the soil material and the

test data

American Association of State Highway and Transportation Officials (AASHTO) (*1*), except as noted]

Mechanical analysis[2]							Liquid limit	Plasticity index	Classification	
Percentage smaller than 3 inches passing sieve—			Percentage smaller than—						AASHTO[3]	Unified[4]
No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)	0.05 mm	0.02 mm	0.005 mm	0.002 mm				
							Percent			
	100	98	90	52	23	16	36	11	A-6	CL-ML
	100	99	95	70	45	37	52	27	A-7-6	CH
	100	98	93	63	33	24	42	20	A-7-6	CL
	100	98	93	58	27	21	39	17	A-6	CL
	100	96	87	51	23	16	39	11	A-6	ML
	100	98	91	65	42	38	52	28	A-7-6	CH
	100	96	89	58	26	18	38	13	A-6	CL-ML
	100	94	87	51	22	15	33	8	A-4	CL-ML
	100	97	91	60	28	22	40	18	A-6	CL
100	99	98	81	59	33	25	40	20	A-6	CL
100	99	94	88	67	37	30	46	24	A-7-6	CL
100	99	90	79	37	14	8	29	5	A-4	CL-ML
	100	95	89	42	12	7	30	6	A-4	CL-ML

would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHTO procedure, the fine material is analyzed by the hydrometer method, and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS procedure, the fine material is analyzed by the pipette method, and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soils.

[3] Based on AASHTO designation M145-49 (*1*).

[4] Based on the Unified soil classification system (*2*).

shrink-swell potential indicate traffic-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and amount of cut and fill needed to reach an even grade.

Sanitary landfill is a method of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted, and covered with soil. Landfill areas are subject to heavy vehicular traffic. Some soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated, the ratings in table 8 apply only to the soil material to a depth of about 6 feet, so a limitation of *slight* or *moderate* may not be valid if trenches are to be much deeper than that. Every site should be investigated before one is selected.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and depth to fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material that is resistant to seepage and piping and that is of favorable stability, shrink-swell potential, shear strength, and campactibility. Stones or organic material in a soil are among factors that are unfavorable.

Terraces and diversions are embankments, or ridges, constructed across the slope to intercept runoff so that it soaks into the soil or flows slowly to a prepared outlet (fig. 22). Features that affect suitability of a soil for terraces are uniformity and steepness of slope; depth to bedrock or to other unfavorable material; presence of stones; permeability; and resistance to water erosion, soil slipping, and soil blowing. A soil suitable for these structures provides outlets for runoff and is not difficult to vegetate.

Irrigation of a soil is affected by such features as slope; susceptibility to stream overflow, erosion, or soil blowing; soil texture; content of stones; accumulation of salts and alkali; depth of root zone; rate of water intake at the surface; permeability below the surface layer and in fragipans or other layers that restrict movement of water; amount of water held available to plants; and need for drainage, or depth to water table or bedrock.

In table 9, soil suitability as a source of construction material is rated *good, fair,* or *poor.* Following are ex-

Figure 22.—**Maintaining terraces on Holdrege soils.**

planations of some of the columns in table 9.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as in preparing a seedbed; natural fertility of the material or plant response when fertilizer is added to the soil; and absence of substances toxic to plants. Texture of the soil material and its content of stone fragments affect suitability. Also considered in the ratings is damage that can result at the area from which topsoil is taken.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 9 provide guidance about where to look for probable sources. A soil rated as a *good* or *fair* source generally has a layer of sand or gravel at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the materials, and neither do they indicate quality of the deposit.

Road fill is soil material used in embankments for roads. The suitability ratings reflect the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage, and the relative ease of excavating the material at borrow areas.

Soil test data

Table 10 contains engineering test data for some of the major soil series in Smith County. The tests were made to help evaluate the soils for engineering purposes. The engineering classifications are based on data obtained by mechanical analyses and by tests to determine liquid limit and plastic limit. The mechanical analyses were made by combined sieve and hydrometer methods.

Moisture-density (or compaction) data are important in earthwork. If a soil material is compacted at successively higher moisture contents, assuming that the compactive effort remains constant, the density of the compacted material increases until the *optimum moisture content* is reached. After that, density decreases with increase in moisture content. The highest dry density obtained in the compaction test is termed *maximum dry density*. As a rule, maximum strength of earthwork is obtained if the soil is compacted to the maximum dry density.

Tests to determine liquid limit and plastic limit measure the effect of water on the consistence of soil material, as has been explained for table 7.

Formation and Classification of the Soils

This section tells how the soils in Smith County formed. It also explains the system of soil classification currently used and classifies the soils of the county according to that system.

Factors of Soil Formation

Soil is produced by soil-forming processes acting on the soil materials deposited or accumulated by natural

forces. The characteristics of the soil at any given point are determined by the physical and mineralogical composition of the parent material; the climate under which the soil material has accumulated and existed since accumulation; the plant and animal life on and in the soil; the relief, or lay of the land; and the length of time the forces of soil formation have acted on the soil material.

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated and slowly change it into a natural body having genetically related horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and in extreme cases may determine it almost entirely.

Finally, time is needed for changing the parent material into the soil profile. It may be much or little, but some time is always required for soil horizon differentiation. Generally, a long time is required for the development of a distinct horizon.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil formation are not well known.

Parent material

The area in which Smith County is located was raised above sea level after the formation of the Permian red beds and subjected to a long period of subaerial erosion. This action lasted throughout the Triassic, Jurassic, and Early Cretaceous periods. Near the close of the Early Cretaceous period, the sea again covered the area, and marine sandstone and shale were deposited on the eroded surface of the Permian rocks. At the beginning of the Late Cretaceous period, the sea withdrew somewhat and the sandstone and clay of the Dakota Formation accumulated under near-shore conditions. The sea again covered the land, and the thick section of Upper Cretaceous shale chalk and limestone that forms the bedrock in this area was deposited. At the close of the Cretaceous period the sea withdrew from the Plains Region, and a continental environment has existed since that time (*7*).

During most of the Tertiary period, western and central Kansas were subject to subaerial erosion and great quantities of Cretaceous rocks were stripped off. As a result of this leveling, the upper surface of the Cretaceous rocks slopes eastward. The moderately deep Wakeen soils formed in soft chalky sediments. The moderately deep Brownell soils and the shallow Heizer soils formed in material derived from soft limestone rocks.

By the late Tertiary period, north-central Kansas was an area of low relief characterized by smooth gentle divides and broad valleys. During the Pliocene period, the streams from the Rocky Mountains that crossed this area spread an apron of alluvial debris on the eroded surface of Cretaceous rocks. The irregularities of the bedrock surface were leveled, and as streams shifted back and forth across the area they built up an eastward sloping alluvial plain called the Ogallala Formation, which may have extended from the Rocky Mountains nearly to the Flint Hills. At the close of the Tertiary period these sediments formed nearly featureless lakes in which the freshwater algal limestone of the Ogallala Formation was forming. Penden soils are deep over soft "mortar bed" caliche sediments, a name applied to clay, silt, sand, and gravel that is locally cemented into a coherent, rather resistant mass. Campus soils are moderately deep over soft caliche, and Canlon soils are shallow over caliche.

The events that formed the present topographic features began with the close of algal limestone deposition and the beginning of Pleistocene erosion. During the early Pleistocene period, streams formed on the plain of the Ogallala Formation and began to cut their way into and through this unconsolidated material. By the Kansan period, major streams had been formed and the approximate pattern of modern drainage was established. The Kansan streams left remnants of coarse channel deposits (Meade Formation) at several locations.

A period of pronounced erosion and downcutting followed this deposition. Valley floors that were being aggraded during this interval probably were the source of the loess of the Loveland silt member of the Sanborn Formation, which was spread over a wide upland area by the wind. The late Sangamon period was apparently a period of essential equilibrium when very little erosion took place and which was ideal for the formation of the well-developed soil of the Loveland member. Nuckolls soils formed in Loveland loess.

During the earliest Wisconsin period, the older deposits were dissected by erosion and the main valley was lowered. Peorian loess covers the upland. This silt was picked up by the wind from the flood plains of the Platte and Republican Rivers and spread in a broad sheet across north-central Kansas. Harney, Holdrege, and Uly soils formed in Peorian loess.

The interval following the deposition of Peorian silt was marked by erosion of the uplands and by cutting of the principal bedrock valley in which the younger terrace deposits accumulated. The deposition of the terrace fill sediments probably took place in the last part of the Wisconsin period and in part of early Recent age. Hord, Roxbury, and McCook soils formed on terraces.

After this period of deposition, the North Fork of the Solomon River was again rejuvenated; it incised its channel 30 feet or more into terrace deposits. The channel continues to cut into bedrock, broaden the flood plain, and meander. Inavale, Munjor, and Roxbury soils formed on the river flood plain. Inavale and Munjor soils are sandy, and Roxbury soils are silty.

Climate

Climate is one of the active factors in soil formation; it has both direct and indirect influence. The amount and distribution of precipitation are direct influences that cause the parent material to slowly weather and change into soil. Climate has an indirect influence

through its effect on the plant and animal life on and in the soil. Where precipitation has been sufficient to maintain plant and animal life, the soils that develop have a dark-colored surface layer.

Smith County has a temperate, continental, subhumid climate. The average annual precipitation is about 22 to 24 inches, a large part of which falls during the growing season. Evaporation is high because of warm temperature and winds.

The effect of climate on the soils of this county varies according to the kind of parent material, the lay of the land, and the time the forces of soil formation have had to act. None of the soils has been excessively leached of plant nutrients. Few soils have been leached of lime to a depth of more than 30 inches. Except for those that formed in noncalcareous alluvium, most of the soils have an accumulation of calcium carbonate within 30 inches of the surface. The cation-exchange capacity of the various soils depends more on the kind of parent material than on the amount of leaching that has occurred.

The climate fluctuates from dry to moist subhumid. This fluctuation may be from year to year or in cycles that cover several years. During dry periods, precipitation and humidity may be well below normal and temperature above normal. In wet periods, the precipitation and humidity are considerably above normal and the temperature is normal or below normal.

The soil profile is dried to varying depths during dry periods. During wet periods it is slowly moistened, and as it becomes saturated excess moisture generally penetrates the underlying material or substratum. The presence of different kinds of concretions in the underlying material indicates the penetration of this excess moisture.

The Harney soils are an example of the influence of climate on the formation of soils. They have smooth, gentle slopes on which the surface drainage is neither restricted nor excessive. These soils formed in pale brown, calcareous loess that is about 20 to 25 percent clay and high in weatherable minerals. They are mature and have a well developed profile. The forces of soil formation are assumed to have had sufficient time to exert their full influence on the profile of the soils. The leaching and weathering of minerals have caused the development of a dark grayish brown eluvial horizon, about 5 to 10 inches thick, and an illuvial horizon about 8 to 16 inches thick. The illuvial horizon has a content of about 35 to 42 percent clay and is high in exchangeable cations.

The alternate wetting and drying has affected the development of the soil profile by slightly leaching bases from the surface layer and even from the lower part of the B horizon. This leaching has left the surface horizon slightly acid or neutral and the lower part of the B horizon at least neutral. In mature soils a distinct structure and clay films are noticeable. Well developed horizons form more in gently sloping soils than in steeper soils because more moisture penetrates the gentle slopes.

Harney soils are leached of free carbonates to a depth of 20 to 30 inches. Below that depth is a zone where calcium carbonate has accumulated. Below a depth of 42 inches these soils have been little affected by the processes of soil formation, except for some accumulation of calcium carbonate.

Weather records in Smith County show that the winters are short and cold and the summers long and hot. About 75 percent of the precipitation falls during the long growing season and accounts for the mid and tall grass vegetation. The vegetation, in turn, reduces the hazard of erosion and removes bases and adds organic matter to the upper part of the soil profile.

Plants and animals

In Smith County the fluctuating, dry to moist subhumid climate favored the growth of mid and tall grasses. The original plant cover on the limy soils consisted mainly of sideoats grama and little bluestem grasses. On the loamy soils it consisted of big bluestem, indiangrass, switchgrass, blue grama, and some buffalograss. Scattered trees grew along most of the larger streams. Some valleys had somewhat open stands of oak, ash, black walnut, hackberry, cottonwood, elm, and willow.

Grass has small, fibrous roots that filled nearly all of the spaces in the upper part of the soil. When these small roots died and decayed they left organic matter evenly distributed throughout the surface layer and caused it to be dark in color.

Decomposed organic matter darkened the soils of Smith County and influenced the development of soil structure. Plant growth and the accumulation of organic matter was greatest in nearly level areas where the available moisture was of most benefit. As a result, the nearly level soils were darkened by organic matter to a greater depth than the more sloping soils.

The plants added organic matter to the soil and thereby influenced its structure and tilth, as well as its chemical characteristics. Plants also affected the temperature within the soil by providing shade and thus helping the soil to retain moisture. Plants not only used much of the precipitation, their roots took up some moisture from the material that underlies the soils in the uplands. As the grass cover spread, it reduced geologic erosion and stabilized the soils. Under the grass cover, the soils formed a thick, dark surface layer.

Additional organic matter that helped to darken the soil was added by animal life on and in the soil. Burrowing animals and earthworms influenced the formation of soils by mixing the organic and mineral parts of the soils. The distinctly granular structure of some soils is the result of worm casts.

Bacteria and fungi live mainly on plant and animal residue. They break down complex compounds into simple forms, as in the decay of organic matter. The simpler compounds supply nutrients for the growth of plants. Substances produced by micro-organisms act as binding agents in the formation of structural peds. Some micro-organisms fix nitrogen from the atmosphere and add it to the soil when they die.

The fibrous root of the grasses drew nutrients from the soil that encouraged a thick cover of vegetation.

As the vegetation decayed, plant nutrients were released and were carried into the soil by permeating moisture. Moderately leached, dark, fertile soils formed as a result of this growth-decay cycle operating in the fluctuating, subhumid, continental type climate.

Relief

Relief, or the lay of the land, affects runoff and drainage and modifies the effect of climate on the parent material. Other factors being equal, an increase in slope results in a corresponding increase in runoff, less moisture gets into the soil, and erosion is greater. As a result, soil development is less rapid. Relief influences soil development, mainly by controlling the movement of water on the surface and into the soil. The Heizer, Canlon, and other thin soils that have strong or steep slopes formed in some of the oldest parent material in the county. Because runoff is rapid on these slopes, much of the soil material is removed as fast as it forms. On the other hand, the terraces have broad areas where the slope is nearly level to gentle and runoff is very slow. In these areas most of the precipitation penetrates the soil, and moderately well developed soils formed in some of the youngest parent materials. On soils formed in recent deposits of loess, the affect of the degree and shape of the slopes is most evident. The well developed Harney soils formed on nearly level to gentle slopes and the less developed Uly soils formed on gentle to strong slopes.

Time

Time is required for the climate and vegetation to change the parent material into soil. On the flood plains, little time is allowed for soil development because soil material is continually deposited and removed. The organic-matter content of the new deposit may differ from the content in the soil covered. Soils other than those on flood plains have reached varying degrees of development since their parent material accumulated. The weak horizonation in the moderately developed soils on terraces indicates that they have been developing for less time than some of the soils on uplands, but this general grouping is broad and is related to geologic time periods. In each group of soils the development of the soil profile is the result of the action of all of the closely interrelated soil-forming factors.

Differences among the soils in this county have been caused mainly by differences in the time that the processes of soil development have had to act on the parent material. For example, Uly and Holdrege soils formed in similar material and in areas of similar topography. The Holdrege soils have darker organic matter to a depth of 12 inches; whereas accelerated erosion has removed the dark surface layer of the Uly soils. The parent material of the Hord and Roxbury soils is nearly uniform, but the more mature Hord soils reflect the longer time that their parent material has been subject to the soil-forming process.

Classification of Soils

The system of classifying soils currently used in the United States was adopted by the National Cooperative Soil Survey in 1965 (*8, 11*). It is under continual study.

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. The criteria for classification are soil properties that are observable or measurable, but the properties are selected so that soils of similar genesis are grouped together. The placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

Table 11 shows the classification of each soil series of Smith County by family, subgroup, and order, according to the current system.

TABLE 11.—*Classification of soil series*

Series	Family	Subgroup	Order
Alluvial land, loamy	Loamy, mixed, mesic	Ustifluvents	Entisols.
Armo	Fine-loamy, mixed, mesic	Entic Haplustolls	Mollisols.
Bogue	Very fine, montmorillonitic, mesic	Udorthentic Pellusterts	Vertisols.
Brownell	Loamy-skeletal, carbonatic, mesic	Entic Haplustolls	Mollisols.
Campus	Fine-loamy, mixed, mesic	Typic Calciustolls	Mollisols.
Canlon	Loamy, mixed (calcareous), mesic	Lithic Ustorthents	Entisols.
Harney	Fine, montmorillonitic, mesic	Typic Argiustolls	Mollisols.
Heizer	Loamy-skeletal, carbonatic, mesic	Lithic Haplustolls	Mollisols.
Holdrege[1]	Fine-silty, mixed, mesic	Typic Argiustolls	Mollisols.
Hord	Fine-silty, mixed, mesic	Pachic Haplustolls	Mollisols.
Inavale	Sandy, mixed, mesic	Typic Ustifluvents	Entisols.
McCook	Coarse-silty, mixed, mesic	Fluventic Haplustolls	Mollisols.
Mento	Fine, montmorillonitic, mesic	Typic Arguistolls	Mollisols.
Munjor	Coarse-loamy, mixed (calcareous), mesic	Typic Ustifluvents	Entisols.
New Cambria	Fine, montmorillonitic, mesic	Cumulic Haplustolls	Mollisols.
Nuckolls	Fine-silty, mixed, mesic	Typic Haplustolls	Mollisols.
Penden	Fine-loamy, mixed, mesic	Typic Calciustolls	Mollisols.
Roxbury	Fine-silty, mixed, mesic	Cumulic Haplustolls	Mollisols.
Uly	Fine-silty, mixed, mesic	Typic Haplustolls	Mollisols.
Wakeen	Fine-silty, carbonatic, mesic	Entic Haplustolls	Mollisols.

[1] The soils in mapping unit Hg are taxadjuncts to the Holdrege series because they are not darkened so deep as defined in the range for the Holdrege series.

ORDER. Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. Three exceptions to this are the Entisols, Histosols, and Vertisols, which occur in many different climates. Each order is named with a work of three or four syllables ending in *sol* (Moll-i-sol).

SUBORDER. Each order is subdivided into suborders using those soil characteristics that seem to produce classes with the greatest genetic similarity. The suborders are more narrowly defined than the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of a water table at a shallow depth, soil climate, the accumulation of clay, iron, or organic carbon in the upper part of the solum, cracking of soils caused by a decrease in soil moisture, and fine stratification. The names of suborders have two syllables. The last syllable indicates the order. An example is *Ustoll; Ust* meaning dry, and *oll,* from mollisol.

GREAT GROUP. Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of soil horizons and features. The horizons used to make separations are those in which clay, carbonates, and other constituents have accumulated or have been removed; and those that have pans that interfere with growth of roots, movement of water, or both. Some features used are soil acidity, soil climate, soil composition, and soil order. The names of great groups have three or four syllables and are made by adding a prefix to the name of the suborder. An example is Argiustoll, *Argi,* meaning developed horizons, *ust* for dry, and *oll,* from mollisols.

SUBGROUP. Great groups are subdivided into subgroups, one representing the central (typic) segment of the group, and others called intergrades that have properties of the group and also one or more properties of another great group, suborder, or order. Other subgroups may have soil properties unlike those of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is Typic Argiustolls (a typical Argiustoll).

FAMILY. Soil families are separated within a subgroup primarily on the basis of properties important to the growth of plants or to the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, soil depth, and consistence. A family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names for texture, mineralogy, and so on, that are used to differentiate families (see table 11). An example is the fine-silty, mixed, mesic family of Typic Argiustolls.

General Facts About the County

The Cheyenne Indians were the inhabitants of what is now Smith County when pioneers began to settle this territory. Smith County was organized in 1872 and named in honor of Civil War veteran J. Nelson Smith, who was killed at the Battle of the Little Blue.

The pioneers were encouraged to settle in the county because of the availability of new land. In the spring of 1870, the territory that is now Smith County had 66 inhabitants. This number increased rapidly from 3,876 in 1872 to 13,904 in 1880 and 15,982 in 1900.

In recent years, there has been a decline in population. The population was 13,545 in 1930, 10,582 in 1940, 8,846 in 1950, 7,776 in 1960, and 6,757 in 1970.

The Rock Island Railroad crosses midway in the county—east to west—and the Missouri Pacific Railroad follows along the north side of the North Fork of the Solomon River in the southwestern part.

Physiography, Relief, and Drainage

Smith County lies in the eastern part of the High Plains section of the Great Plains physiographic province (fig. 23).

The climate of the county is the continental subhumid type characterized by relatively cold winters and warm summers. The principal source of moisture is tropical air from the Gulf of Mexico. The average annual precipitation is about 24 inches.

The uplands throughout the county are covered with wind-blown silty loess. Nearly level to gently sloping areas are in the central part. The loess cap is thinner in the southern part. In the northern part the loess is very deep and the land is more sloping. Erosion has formed the present landscape. The major topographic features are controlled by the underlying bedrock or have been modified by Pleistocene age deposition and erosion.

The Blue Hill shale of the Carlile Formation outcrops in the southern part of the county. The soils that formed from this shale are clayey, droughty, and have poor tilth.

The Niobrara Formation consists of Smoky Hill chalk and Fort Hays limestone. It outcrops on the steeper slopes along the major streams and upland drainageways of the county. Moderately deep and shallow soils formed in sediments derived from the soft chalk and limestone.

The Ogallala Formation consists of opaline sandstone and soft and hard caliche sediments and is in the northwestern part of the county. These limy sediments are on moderately sloping to strongly sloping and broken upland slopes.

The elevation at Smith center is 1,800 feet above sea level. The highest elevation is 2,000 feet in the uplands of the northwestern part, and the lowest elevation is 1,500 feet in the southeastern part along Oak Creek.

A narrow upland divide is near the northern boundary of this county. Walnut creek is the major stream flowing north to the Republican River.

White Rock Creek drains the northeastern part of the county and flows east.

The North Fork of the Solomon River cuts across the southwestern part of the county. Madison Creek and other upland drains flow north to the river; Cedar, Beaver, Spring, Dry, and Oak Creeks flow south to the river.

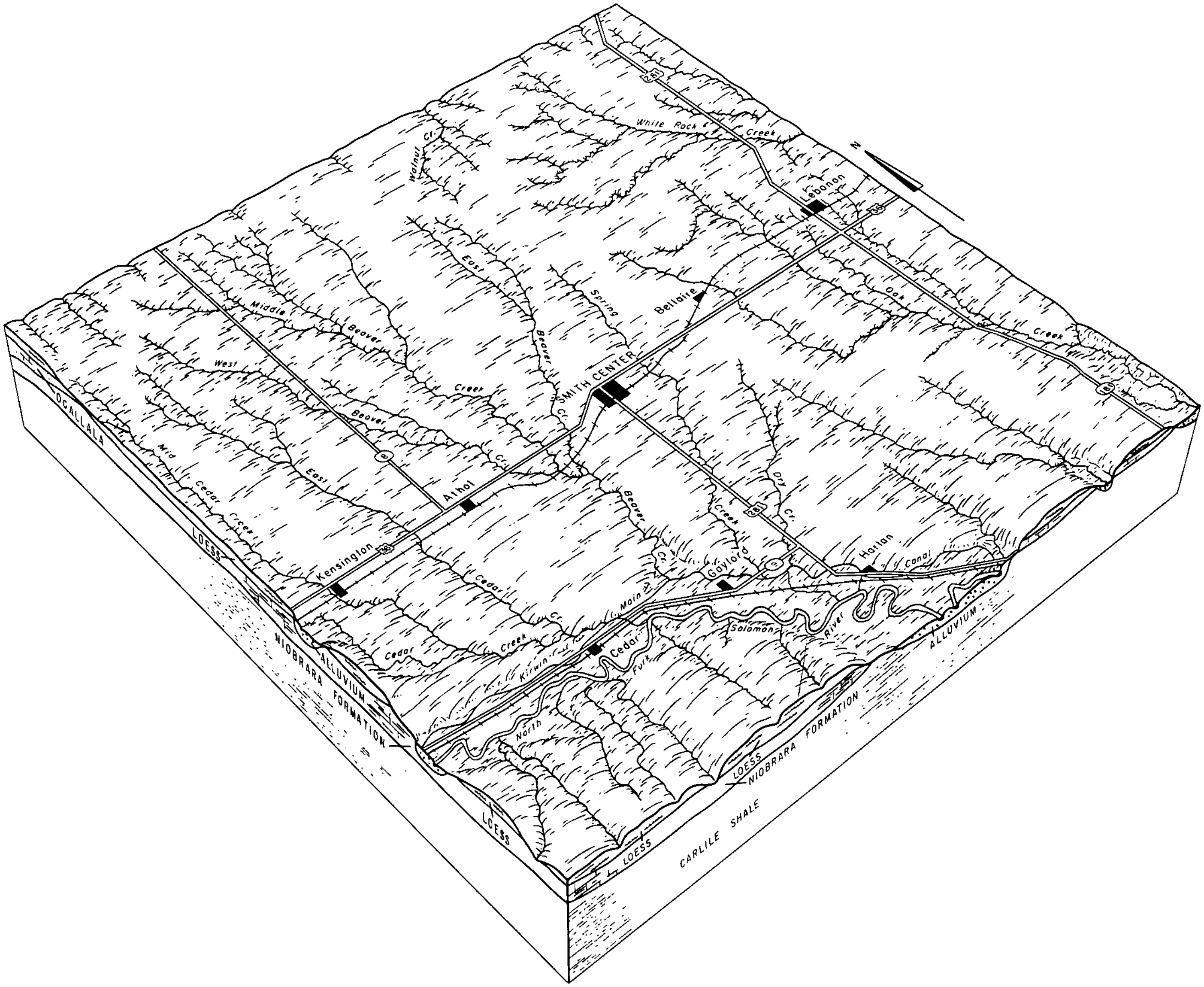

Figure 23.—**Relief and drainage of Smith County.**

These streams have narrow, low flood plains along the channels. Nearly level, dark, deep, and fertile soils are on the high flood plains between the uplands and the low flood plains.

Water Supply

Most domestic wells of the county are drilled or dug in alluvium in the drainageways and along streams; a few are in the uplands. A few irrigation water wells have been developed along the North Fork of the Solomon River. There are several wells used for irrigation in the uplands.

Most of the wells are for domestic use. Nearly all the land under irrigation in the North Fork of the Solomon River Valley is watered from the Kirwin Ditch.

Many dams have been built on the uplands to impound water for livestock. Several ponds are used for irrigation.

Climate[8]

The climate of Smith County is a typical continental type. This would be expected from its location in the interior of a large land mass in middle latitudes. Such climates are characterized by large diurnal and annual variations in temperature. This feature of the climate is similar to all of Kansas and, indeed, to much of the area between the Rockies to the west and the Appalachian Mountains to the east.

[8] By L. DEAN BARK, climatologist, Kansas Agricultural Experiment Station, Manhattan.

The climate of Smith County has been classified by Thornthwaite as dry subhumid (*9*). Precipitation in such a climate "does not exceed the losses by evaporation and the needs of plants, and no water is available as surface runoff. As a consequence, there is no accretion to ground water, except in rainy years, and the subsoil is virtually permanently dry." Although this classification describes Smith County under average conditions, there are occasional years in which rainfall totals are high. Smith County is near the boundary between the dry part of western Kansas, which is influenced by the rain shadow of the Rockies, and the moist eastern regions of the State, which are frequently visited by moisture-laden air currents from the Gulf of Mexico (*4*). The annual rainfall depends on the outcome of the battle between these two influential factors.

Climatological records have been made at a number of locations in Smith County since the turn of the century. Since 1910, precipitation records have been essentially continuous at Smith Center. Temperature observations have been less consistent. The current record of temperature at Smith Center began in 1951. There are some earlier temperature records taken at that location prior to 1925, and at Lebanon before 1914. The climatic data for Smith County in table 12 are based on an analysis of the Smith Center records and those of nearby Alton in Osborne County.

Precipitation totals for the year in Smith County average about 24 inches. Almost 80 percent of this annual total occurs in the growing season from April through September. There are measurable amounts of precipitation on an average of 63 days a year. The months with the highest average number of rainy days are May, with 8, and June, with 9. These are also the months that have the highest average amounts of precipitation. The amount of precipitation on a majority of the rainy days is very light; half have less than 0.25 inch recorded. About 10 percent of the rainy days have over 1 inch. The 11 days having the greatest precipitation totals contribute 50 percent of the annual total; the remaining 50 percent is spread over 52 days. There are commonly 2 or 3 weeks of dry weather between showers, and these dry spells can produce stress conditions in cultivated crops, native pastures, and meadows.

Most of the annual precipitation total comes from convective shower activity. Thunderstorms move across the county usually in the evening or during the night. It rains most frequently during the period from 1 to 3 a.m. Forty percent of the hours when it rains are between midnight and 6 a.m. It rains only 30 percent of the hours during the peak outdoor work period from 6 a.m. to 6 p.m.

Snowfall averages about 18 inches a year in Smith County. Amounts are fairly evenly divided among the months from December through March. The maximum amount tends to be in February. The most snow recorded in a calendar year at Smith Center was 37.8 inches in 1958. Of that amount, 22 inches fell in March. The winter of 1957-58 had a total of 47.6 inches of snow. In general, snow remains on the ground for periods of less than a week. There are occasional exceptions. In 1960 there was at least a trace of snow on the ground at Smith Center from the last week in January until the end of March. There are blizzards

TABLE 12.—*Temperature and precipitation*

[From records kept at Smith Center for the period 1941-70]

Month	Temperature				Precipitation		
	Average daily maximum[1]	Average daily minimum[1]	Two years in 10 will have about 4 days with—[2]		Average monthly total	One year in 10 will have—	
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Totals less than—	Totals greater than—
	°F	*°F*	*°F*	*°F*	*Inches*	*Inches*	*Inches*
January	40.1	14.8	57	—5	0.41	0.04	1.10
February	46.8	19.6	64	2	.64	[3]T	1.15
March	54.2	26.1	77	9	1.35	.13	2.90
April	67.9	39.4	84	26	2.09	.18	4.07
May	76.5	50.0	93	37	3.51	1.25	6.33
June	86.0	60.4	100	50	4.66	1.53	7.58
July	91.9	65.4	105	56	3.29	1.25	6.10
August	91.4	64.2	103	54	2.86	.89	5.22
September	82.5	54.0	96	41	2.62	.80	5.05
October	72.3	42.0	87	28	1.44	.25	3.41
November	55.8	27.5	69	14	.62	T	1.59
December	43.8	18.1	61	1	.54	T	1.27
Year	67.5	40.1	[4]106	[5]—12	24.03	15.32	31.93

[1] For the period 1956-73.
[2] From records kept at Alton for the period 1941-70.
[3] T = Trace.
[4] Average annual highest temperature.
[5] Average annual lowest temperature.

at times during the snow season, especially early in spring, but they are usually of short duration.

The range in temperature is large in a continental climate. Annual extremes in Smith County are generally from –5° and –10° to 105°. The lowest temperature ever recorded in the state of Kansas was –40° at Lebanon on February 13, 1905. Temperature records were not taken in the county during the 1930's, but Phillipsburg reported 120° and Alton 121° on July 24, 1936. Extremely cold periods are associated with snow-covered ground and clear nights. Fortunately, the snow acts as insulation for winter wheat, lawns, and dormant plants.

The average temperature data in table 12 indicate that the transition seasons of spring and fall in Kansas are rather short. The winter months are December through February, and the average daily temperatures are in the 30's or lower. The warm summer temperatures necessary for plant growth continue from late April into early October.

The average growing season (period between 32° freezes in spring and fall) is 165 days in Smith County. There is little crop damage from freezing weather in most years. Freezes late in spring occasionally damage winter wheat. The probability of freezes of differing severity in the spring and fall are given in table 13 (*3*).

The prevailing wind direction is southerly, but northerly winds are common, particularly in winter. Average wind velocities are moderately strong in all seasons but reach a maximum during spring. Average hourly wind velocity in March, the windiest month, is about 14 miles per hour.

Although climatic conditions in Smith County are generally favorable for successful agricultural production, a lack of soil moisture often reduces crop yields on nonirrigated farms. The greatest damage occurs when high temperatures, dry weather, strong winds, and low humidities combine to produce high moisture demand. During such periods evapotranspiration rates are high and crop plants are unable to maintain satisfactory growth. If the crop cover is limited, conditions are ideal for erosion. During the period from 1931 to 1968, droughts classified as mild, moderate, severe, or extreme were recorded during 197 months (*5*). There were severe or extreme drought periods in 88 months or about 20 percent of the period of study. These figures are perhaps higher than average since the period of study includes the devastating droughts of the 30's and 50's. Although a longer period of study might show a shorter time of severe and extreme drought, those farming in this section of Kansas need to be aware of the high potential for drought.

Smith County has occasional tornadoes and severe windstorms, which are associated with the passage of squall lines through the State. It is somewhat removed from the center of maximum tornadoes in east-central Oklahoma, however, and the threat of such storms is correspondingly low. When they do occur, these storms are local in extent and of short duration so that risk of damage is small. The county is nearer to the center of maximum occurrence of hail storms (northeastern Colorado, southeastern Wyoming, Nebraska panhandle). Hail is associated with heavy rains, and thus the months of May and June are the months of most frequent hail. Unfortunately this is also a critical period in the development and harvest of winter wheat. Crop losses from hail are heavy in some years.

Farming

According to the U.S. Census of Agriculture, there were 980 farms in Smith County in 1969. The average size of farms was 578.8 acres. They ranged from 239 farms that were less than 220 acres in size to 15 farms that were 2,000 acres and more in size.

Farm operators were classified as follows: full owners, 367; part owners, 438; and tenants, 175.

Cash grain amounted to a large part of the annual crop production.

The land in Smith County, according to the 1967 Conservation Needs Inventory, is used as follows: about 61 percent, or 337,188 acres, is used for crops, of which 7,100 acres is irrigated; 38 percent is range and forest or woodland; and 1 percent is used for cities, roads, railroads, cemeteries, and parks.

Wheat and grain sorghums are the most important crops grown under normal conditions. About 7,100 acres are irrigated from the Kirwin Ditch, wells, or dugouts. Crops grown under irrigation are wheat, alfalfa, corn, soybeans, grain sorghum, and silage crops.

In 1972, according to the Kansas State Board of Agriculture (*6*), wheat was sown on 96,000 acres and harvested from 94,000 acres. Also harvested were sor-

TABLE 13.—*Probabilities of last freezing temperatures in spring and first in fall*

Temperature probability	16° F or lower	20° F or lower	24° F or lower	28° F or lower	32° F or lower
Spring:					
1 year in 10 later than	April 8	April 17	April 19	May 5	May 16
2 years in 10 later than	April 2	April 11	April 14	April 30	May 11
5 years in 10 later than	March 21	April 1	April 5	April 20	May 1
Fall:					
1 year in 10 earlier than	October 27	October 19	October 16	October 6	September 26
2 years in 10 earlier than	November 3	October 24	October 20	October 11	September 30
5 years in 10 earlier than	November 15	November 4	October 30	October 20	October 10

ghum for grain from 59,000 acres, sorghum for silage from 8,100 acres, corn for grain from 7,100 acres, corn for silage from 1,700 acres, alfalfa from 19,000 acres, and wild hay from 4,000 acres.

Livestock raising is an increasingly important enterprise. The cow herds are increasing in number in the county. The number of farm feedlots is also increasing. In 1972 there were 32,000 beef cows, 1,700 milk cows, 48,300 other cattle, 47,000 hogs, 2,000 sheep and lambs, and 16,000 chickens.

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Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as crumbs, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Blowout. An excavation produced by wind action in loose soil, usually sand.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Caliche. A more or less cemented deposit of calcium carbonate in many soils of warm-temperate areas, as in the Southwestern States. The material may consist of soft, thin layers in the soil or of hard, thick beds just beneath the solum, or it may be exposed at the surface by erosion.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Ground water (geology). Water that fills all the unblocked pores of underlying material below the water table, which is the upper limit of saturation.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O Horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A Horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually

underlies a C horizon but may be immediately beneath an A or B horizon.

Loess. Fine-grained material, dominantly of silt-sized particles, that has been deposited by wind.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

pH value. A numerical means for designating acidity and alkalinity in soils. A pH value of 7.0 indicates precise neautrality; a higher value, alkalinity; and a lower value, acidity.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Sedimentary rock. A rock composed of particles deposited from suspension in water. The chief sedimentary rocks are conglomerate, from gravel; sandstone, from sand; shale, from clay; and limestone, from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sands have been consolidated into sandstone.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular. Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles, adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

GUIDE TO MAPPING UNITS

For a complete description of a mapping unit, read both the description of the mapping unit and the description of the soil series to which the mapping unit belongs. Range sites are described beginning on page 38. Windbreak suitability groups are described on pages 41 and 42.

Map symbol	Mapping unit	Page	Capability unit, Dryfarmed	Capability unit, Irrigated	Range site	Windbreak suitability group
			Symbol	Symbol	Name	Number
Aa	Alluvial land, loamy	12	Vw-1	-------	Loamy Lowland	1
Ar	Armo loam, 2 to 7 percent slopes	14	IIIe-2	-------	Limy Upland	3
Bo	Bogue clay, 3 to 15 percent slopes	15	VIe-5	-------	Blue Shale	--
Br	Brownell gravelly loam, 3 to 15 percent slopes	16	VIe-4	-------	Limy Upland	3
Cc	Campus-Canlon complex, 5 to 30 percent slopes	17	VIe-2	-------	--------------	--
	Campus soil	--	-------	-------	Limy Upland	3
	Canlon soil	--	-------	-------	Shallow Limy	--
Ha	Harney silt loam, 0 to 1 percent slopes	18	IIc-1	I-2	Loamy Upland	2
Hb	Harney silt loam, 1 to 3 percent slopes	19	IIe-3	IIe-3	Loamy Upland	2
Hc	Harney-Mento silt loams, 3 to 7 percent slopes	19	IVe-1	-------	Loamy Upland	2
Hd	Heizer-Brownell complex, 7 to 30 percent slopes	20	VIIs-1	-------	--------------	--
	Heizer soil	--	-------	-------	Shallow Limy	--
	Brownell soil	--	-------	-------	Limy Upland	3
He	Holdrege silt loam, 1 to 3 percent slopes	21	IIe-1	IIe-1	Loamy Upland	2
Hf	Holdrege silt loam, 3 to 7 percent slopes	21	IIIe-1	-------	Loamy Upland	2
Hg	Holdrege silty clay loam, 3 to 7 percent slopes, eroded	22	IIIe-3	-------	Loamy Upland	2
Hh	Hord silt loam	23	I-1	I-1	Loamy Terrace	1
Im	Inavale-Munjor complex	24	IVe-4	-------	--------------	--
	Inavale soil	--	-------	-------	Sands	--
	Munjor soil	--	-------	-------	Sandy	1
Ma	McCook silt loam	24	I-1	I-1	Loamy Terrace	1
Mm	McCook-Munjor complex	24	IIw-1	IIw-1	Loamy Lowland	1
Nc	New Cambria silty clay	26	IIs-1	IIs-1	Clay Terrace	1
Nd	Nuckolls silt loam, 7 to 12 percent slopes	27	IVe-3	-------	Loamy Upland	2
Nh	Nuckolls-Holdrege silt loams, 3 to 7 percent slopes	27	IIIe-1	-------	Loamy Upland	2
Pe	Penden loam, 3 to 7 percent slopes	28	IIIe-4	-------	Limy Upland	3
Ro	Roxbury silt loam	28	I-1	I-1	Loamy Terrace	1
Rp	Roxbury silt loam, frequently flooded	29	IIIw-1	-------	Loamy Lowland	1
Rr	Roxbury-Armo complex, 0 to 3 percent slopes	29	IIe-2	IIe-2	--------------	--
	Roxbury soil	--	-------	-------	Loamy Lowland	1
	Armo soil	--	-------	-------	Limy Upland	3
Uh	Uly-Holdrege silt loams, 7 to 12 percent slopes	30	IVe-3	-------	Loamy Upland	2
Ur	Uly-Roxbury silt loams, 0 to 30 percent slopes	30	VIe-1	-------	--------------	--
	Uly soil	--	-------	-------	Loamy Upland	2
	Roxbury soil	--	-------	-------	Loamy Lowland	1
Wc	Wakeen silt loam, 3 to 7 percent slopes	31	IVe-2	-------	Limy Upland	3
Wd	Wakeen complex, 5 to 20 percent slopes	32	VIe-3	-------	Limy Upland	3

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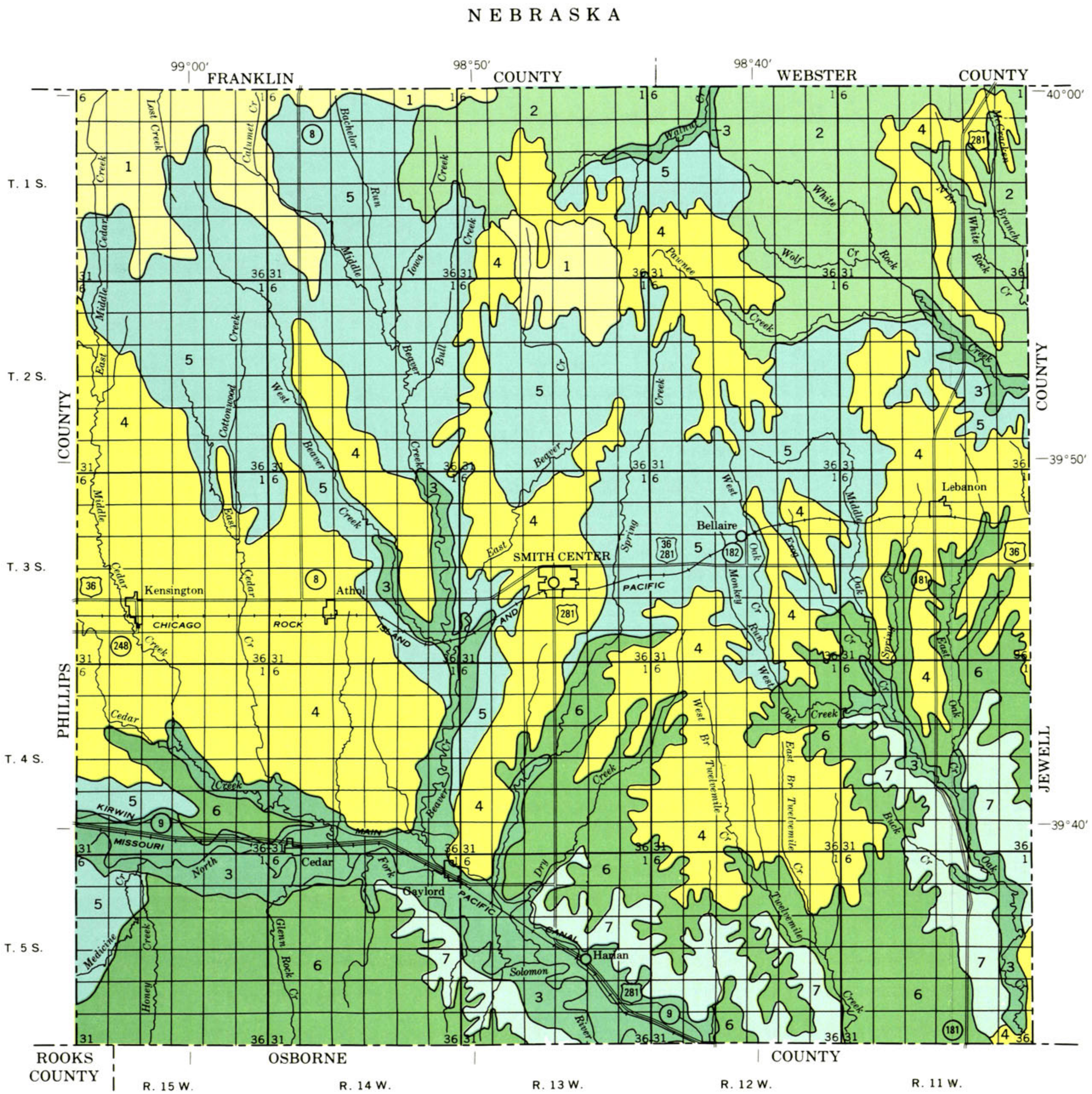


U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
KANSAS AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP

SMITH COUNTY, KANSAS

Scale 1:253,440

1 0 1 2 3 4 Miles

SOIL ASSOCIATIONS

1 — Uly - Holdrege - Campus association: Deep and moderately deep, gently sloping to steep, well drained, silty and loamy soils that formed in loess and caliche sediment on uplands

2 — Holdrege - Uly - Nuckolls association: Deep, gently sloping to steep, well drained, silty soils that formed in loess on uplands

3 — Roxbury - McCook - Hord association: Deep, nearly level, well drained, silty soils that formed in alluvium on lowlands

4 — Harney - Holdrege - Hord association: Deep, nearly level to strongly sloping, well drained, silty soils that formed in loess on uplands and alluvium on terraces

5 — Holdrege - Wakeen - Roxbury association: Deep and moderately deep, nearly level to moderately steep, well drained, silty soils that formed in loess and chalky shale on uplands and loamy alluvium on lowlands

6 — Harney - Mento - Brownell association: Deep and moderately deep, nearly level to strongly sloping, well drained, silty to gravelly loamy soils that formed in loess an and chalky limestone on uplands

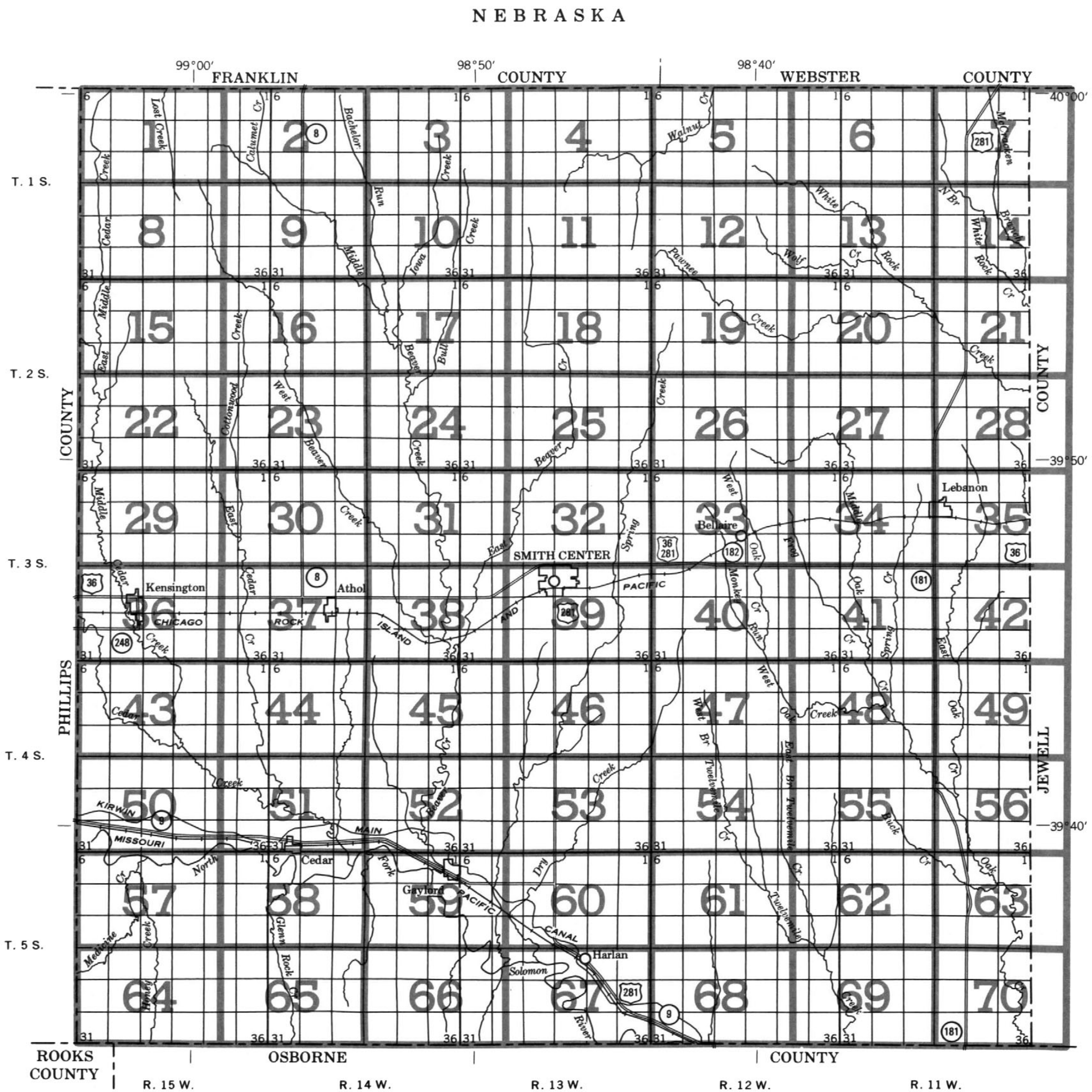
7 — Heizer - Armo - Bogue association: Shallow to deep, sloping to steep, somewhat excessively drained to moderately well drained, gravelly loamy, loamy, and clayey soils that formed in chalky limestone, alluvium, and clayey shale on uplands

Compiled 1977

SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.



INDEX TO MAP SHEETS

SMITH COUNTY, KANSAS

Scale 1:253,440

1 0 1 2 3 4 Miles

SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

SOIL LEGEND

SYMBOL	NAME
Aa	Alluvial land, loamy
Ar	Armo loam, 2 to 7 percent slopes
Bo	Bogue clay, 3 to 15 percent slopes
Br	Brownell gravelly loam, 3 to 15 percent slopes
Cc	Campus-Canlon complex, 5 to 30 percent slopes
Ha	Harney silt loam, 0 to 1 percent slopes
Hb	Harney silt loam, 1 to 3 percent slopes
Hc	Harney-Mento silt loams, 3 to 7 percent slopes
Hd	Heizer-Brownell complex, 7 to 30 percent slopes
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Hf	Holdrege silt loam, 3 to 7 percent slopes
Hg	Holdrege silty clay loam, 3 to 7 percent slopes, eroded
Hh	Hord silt loam
Im	Inavale-Munjor complex
Ma	McCook silt loam
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Uh	Uly-Holdrege silt loams, 7 to 12 percent slopes
Ur	Uly-Roxbury silt loams, 0 to 30 percent slopes
Wc	Wakeen silt loam, 3 to 7 percent slopes
Wd	Wakeen complex, 5 to 20 percent slopes

CONVENTIONAL AND SPECIAL SYMBOLS LEGEND

CULTURAL FEATURES

BOUNDARIES

- National, state or province
- County or parish
- Minor civil division
- Reservation (national forest or park, state forest or park, and large airport)
- Land grant
- Limit of soil survey (label)
- Field sheet matchline & neatline

AD HOC BOUNDARY (label)

- Small airport, airfield, park, oilfield, cemetery, or flood pool

STATE COORDINATE TICK

LAND DIVISION CORNERS (sections and land grants)

ROADS

- Divided (median shown if scale permits)
- Other roads
- Trail

ROAD EMBLEMS & DESIGNATIONS

- Interstate
- Federal
- State
- County, farm or ranch

RAILROAD

POWER TRANSMISSION LINE (normally not shown)

PIPE LINE (normally not shown)

FENCE (normally not shown)

LEVEES

- Without road
- With road
- With railroad

DAMS

- Large (to scale)
- Medium or small

PITS

- Gravel pit
- Mine or quarry

MISCELLANEOUS CULTURAL FEATURES

- Farmstead, house (omit in urban areas)
- Church
- School
- Indian mound (label)
- Located object (label)
- Tank (label)
- Wells, oil or gas
- Windmill
- Kitchen midden

WATER FEATURES

DRAINAGE

- Perennial, double line
- Perennial, single line
- Intermittent
- Drainage end
- Canals or ditches
  - Double-line (label)
  - Drainage and/or irrigation

LAKES, PONDS AND RESERVOIRS

- Perennial
- Intermittent

MISCELLANEOUS WATER FEATURES

- Marsh or swamp
- Spring
- Well, artesian
- Well, irrigation
- Wet spot

SPECIAL SYMBOLS FOR SOIL SURVEY

SOIL DELINEATIONS AND SYMBOLS

ESCARPMENTS

- Bedrock (points down slope)
- Other than bedrock (points down slope)

SHORT STEEP SLOPE

GULLY

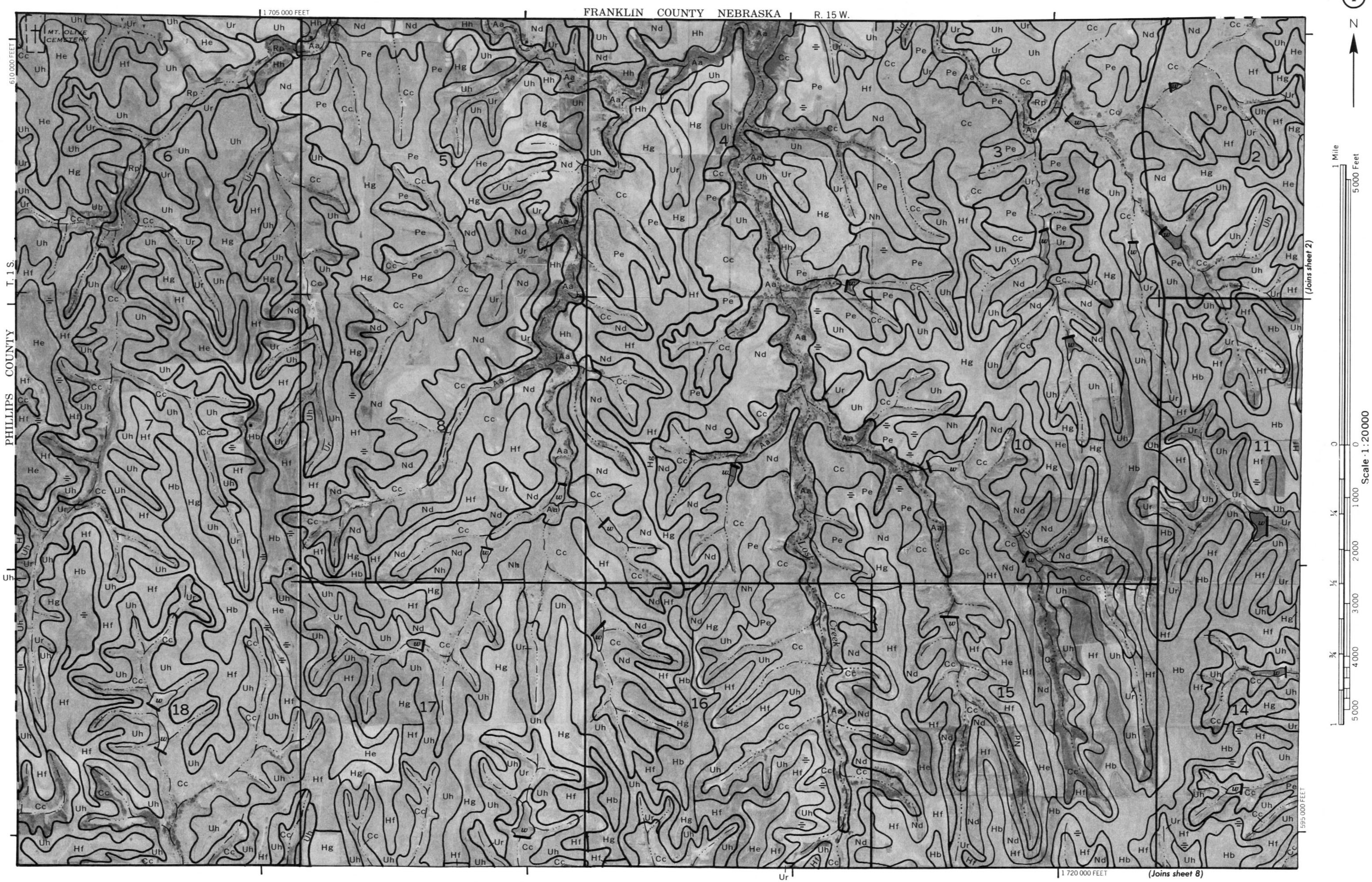
DEPRESSION OR SINK

SOIL SAMPLE SITE (normally not shown)

MISCELLANEOUS

- Blowout
- Clay spot
- Gravelly spot
- Gumbo, slick or scabby spot (sodic)
- Dumps and other similar non soil areas
- Prominent hill or peak
- Rock outcrop (includes sandstone and shale)
- Saline spot
- Sandy spot
- Severely eroded spot
- Slide or slip (tips point upslope)
- Stony spot, very stony spot

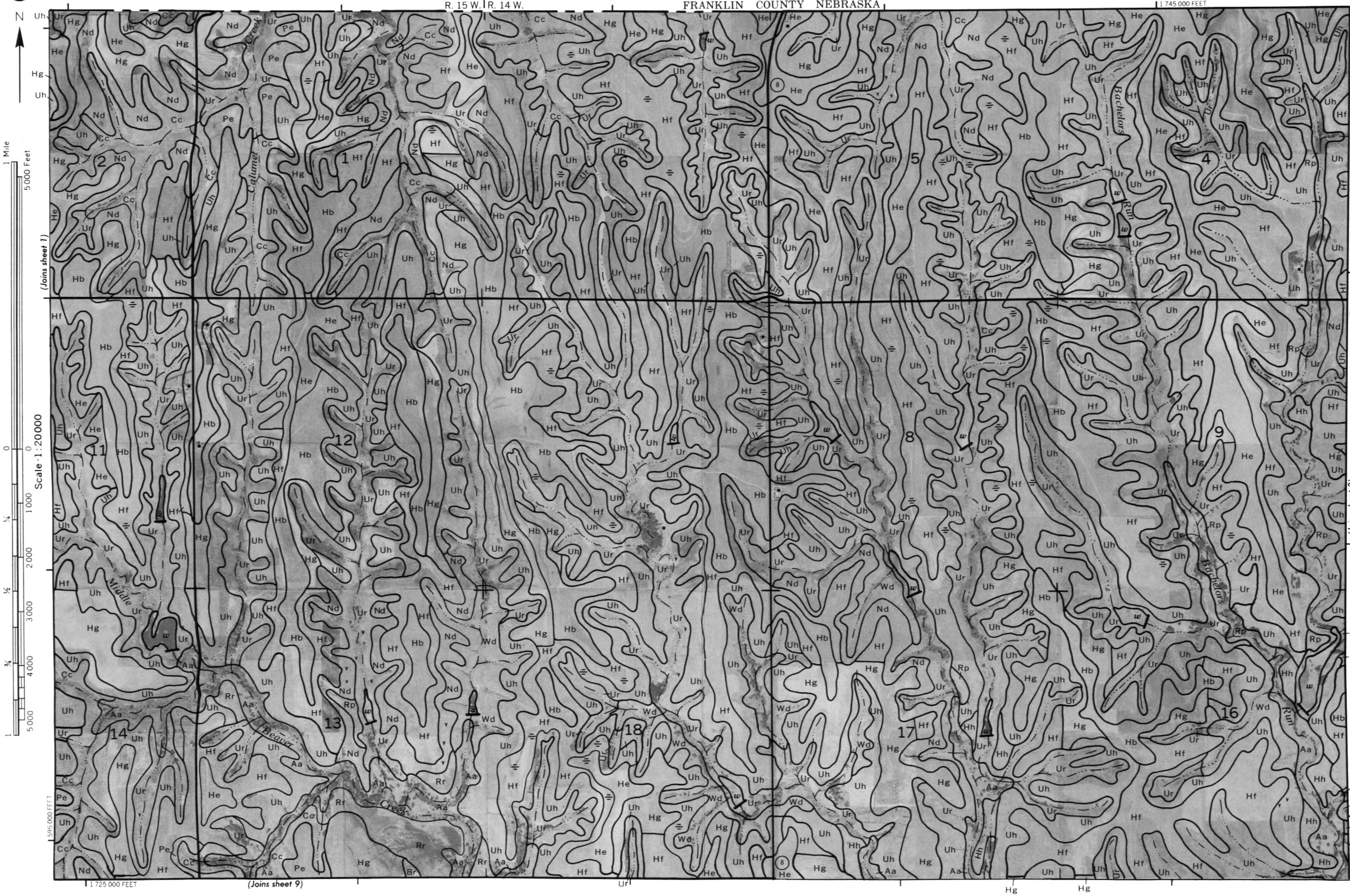
SMITH COUNTY, KANSAS — SHEET NUMBER 1



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

2

SMITH COUNTY, KANSAS — SHEET NUMBER 2



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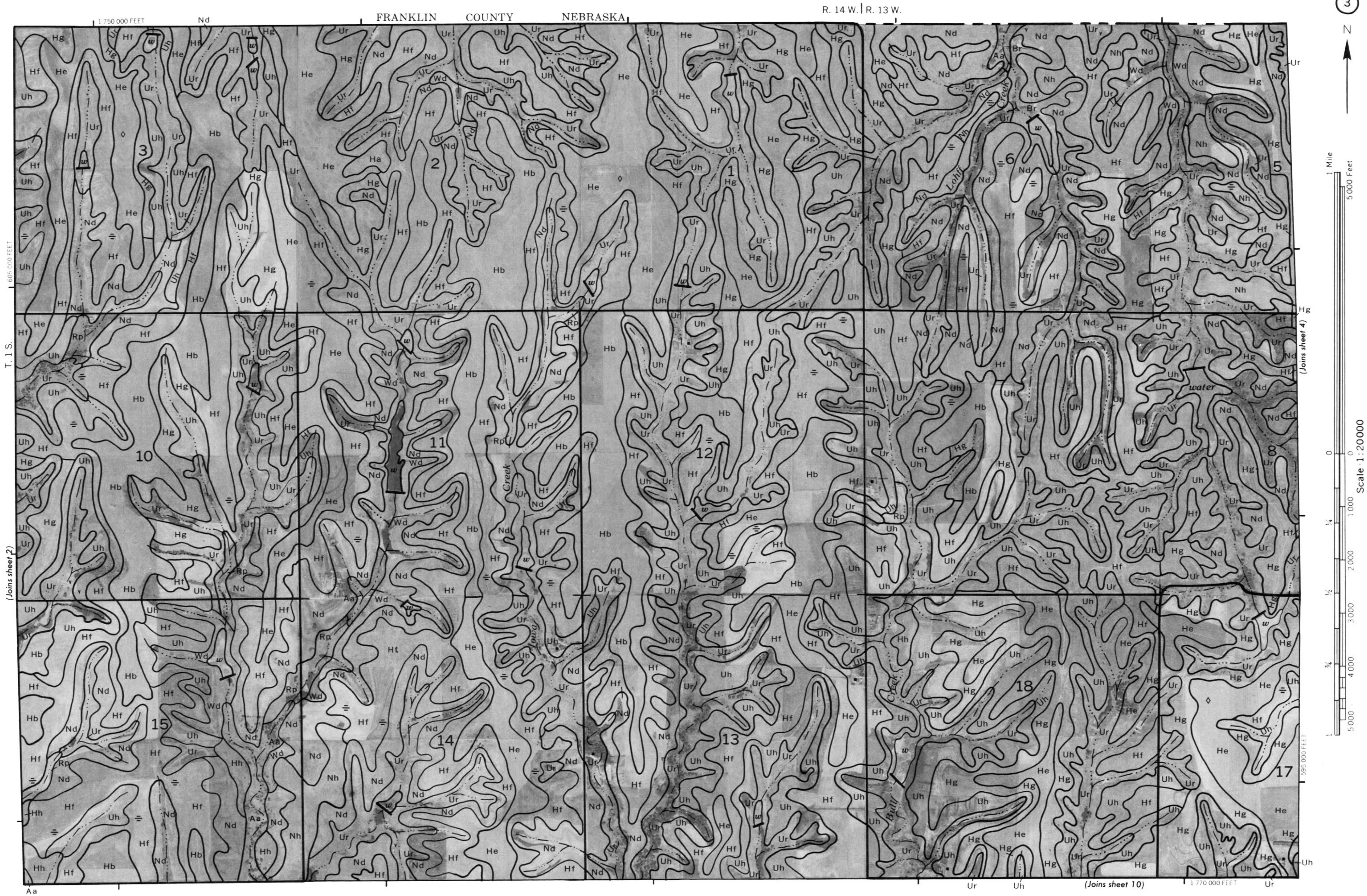
FRANKLIN COUNTY NEBRASKA
1 750 000 FEET
R. 14 W. | R. 13 W.
N
T. 1 S.
605 000 FEET
(Joins sheet 2)
(Joins sheet 4)
(Joins sheet 10)
595 000 FEET
1 770 000 FEET
water
Creek
Long
Lohff Creek
Bull Creek
1 Mile
5000 Feet
Scale 1:20000
1
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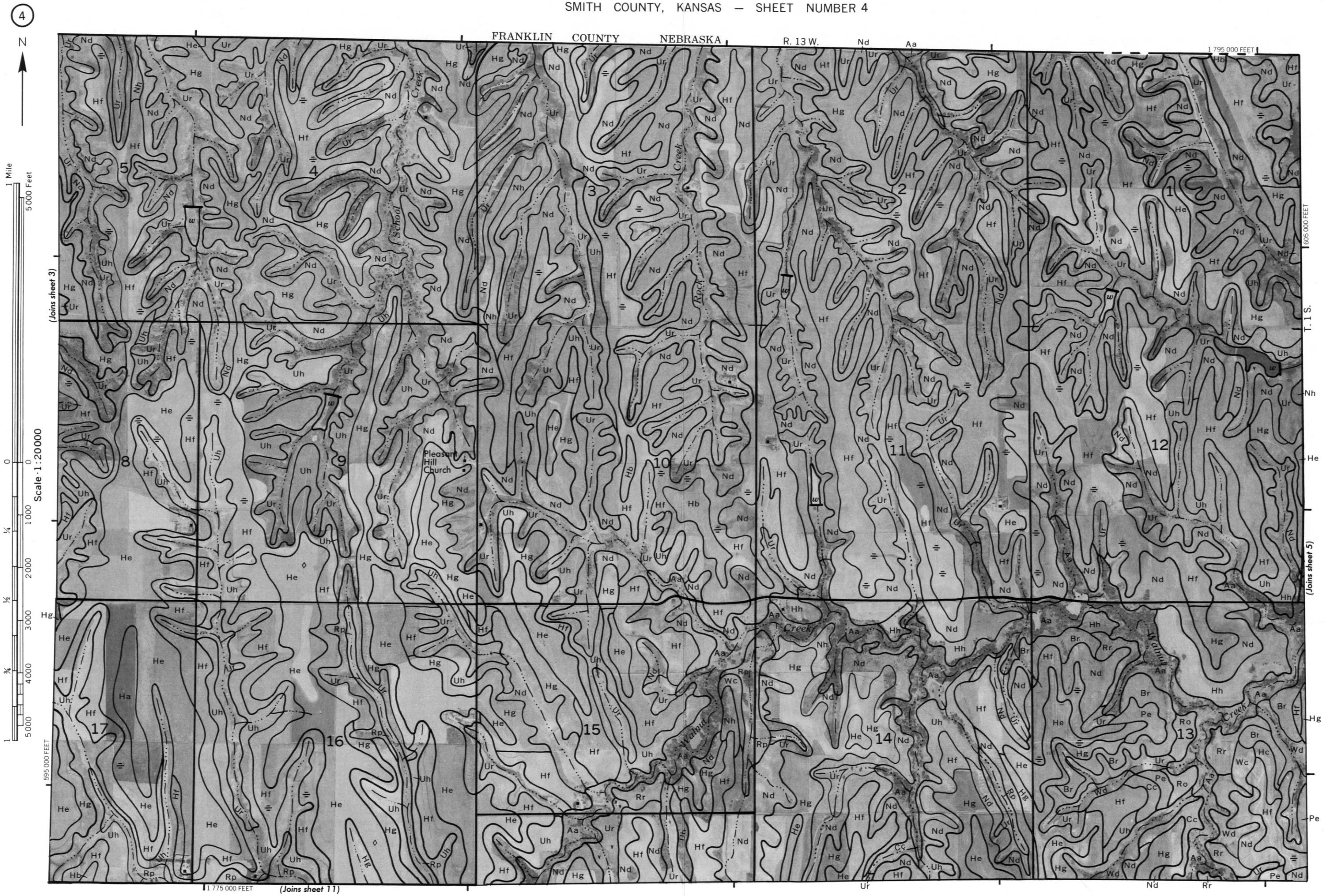
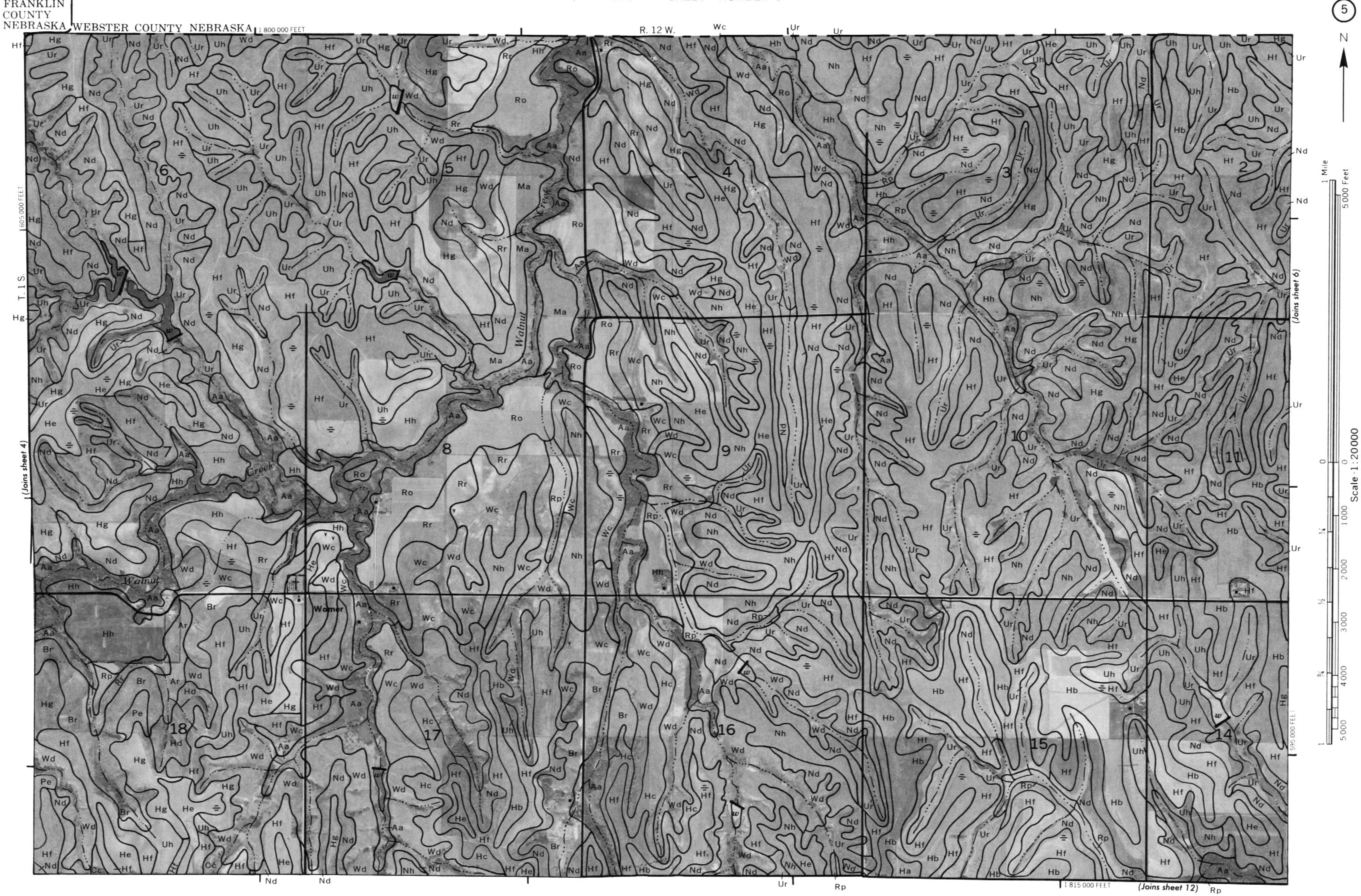
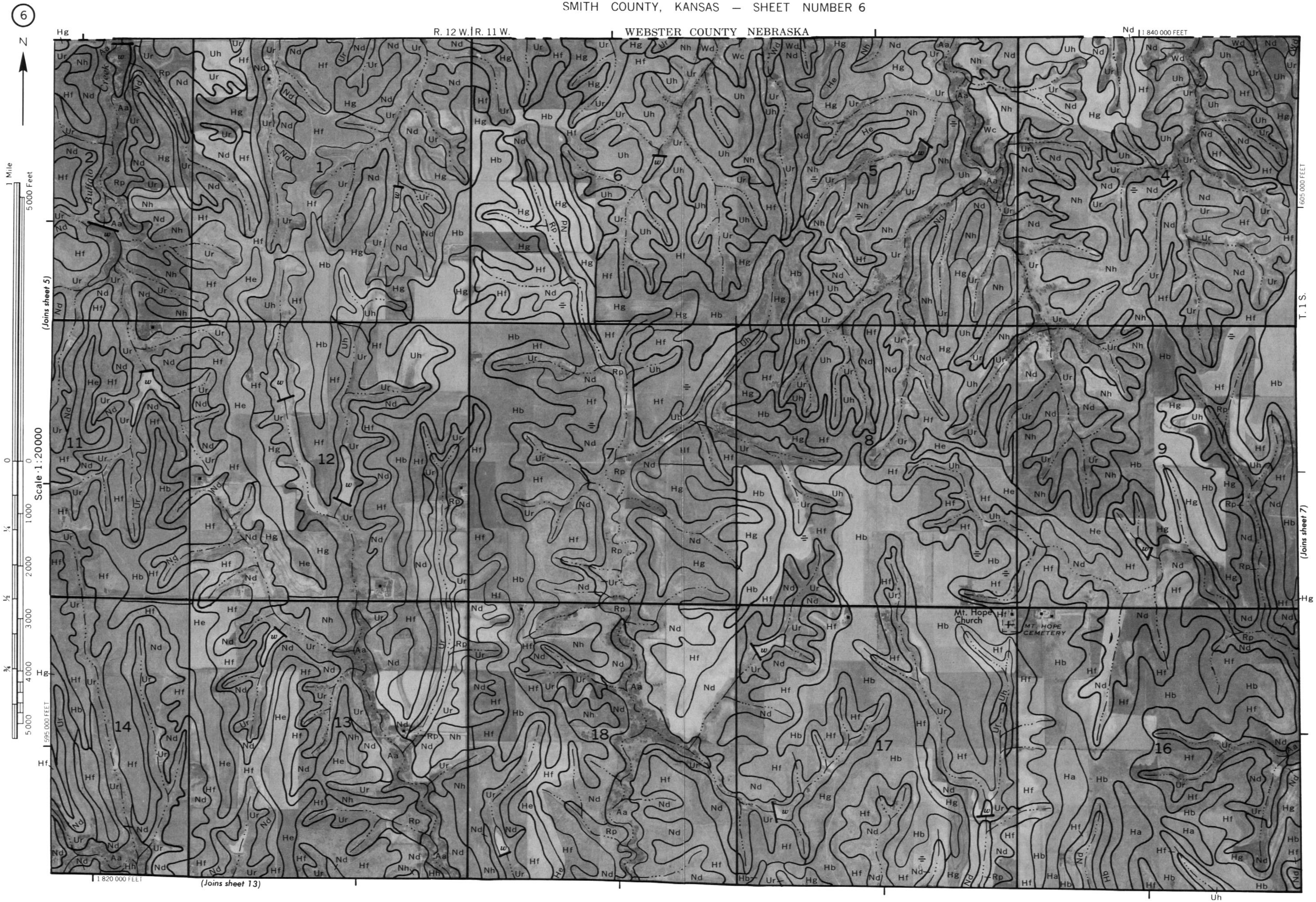
17
18



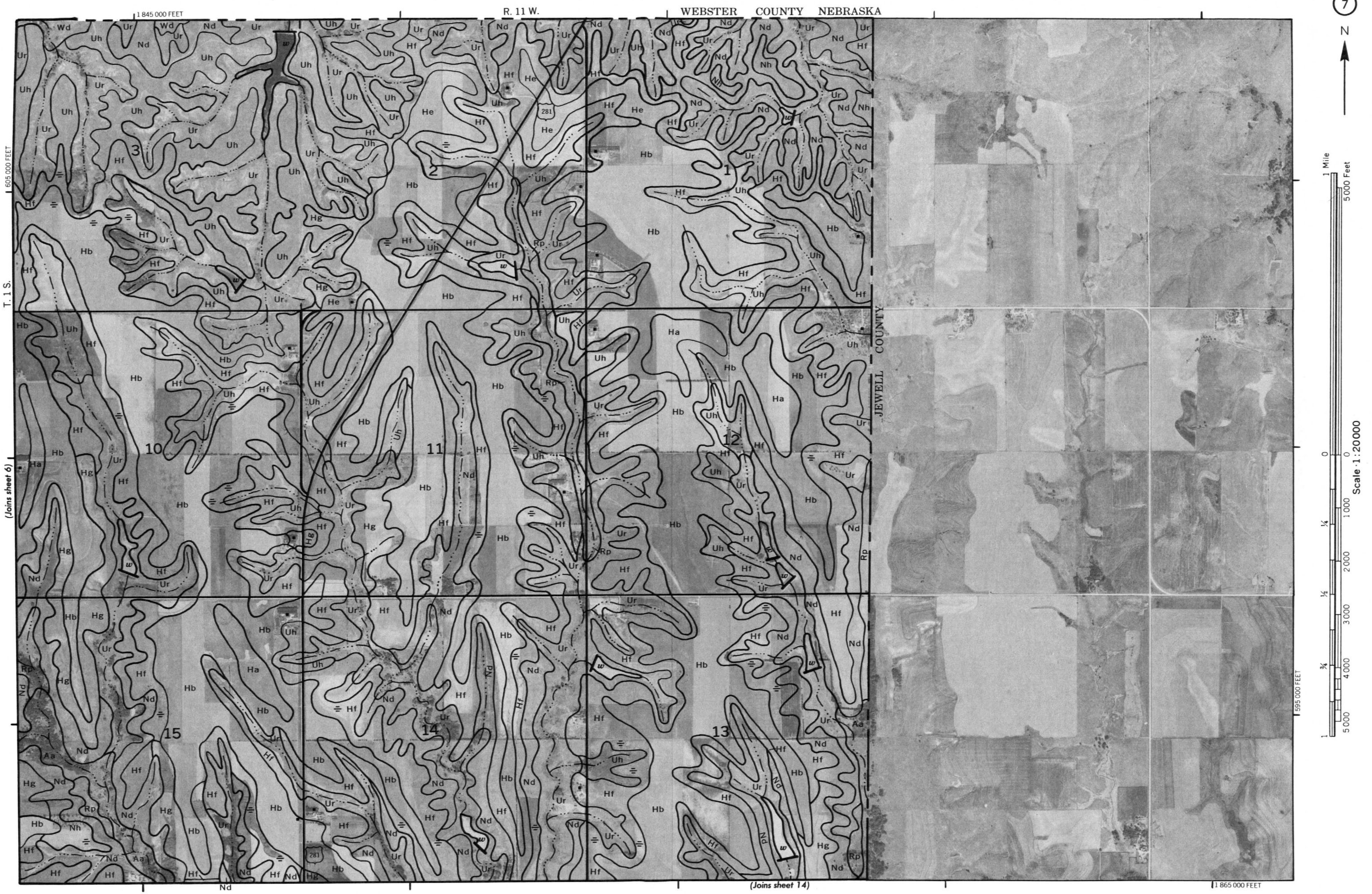
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 5

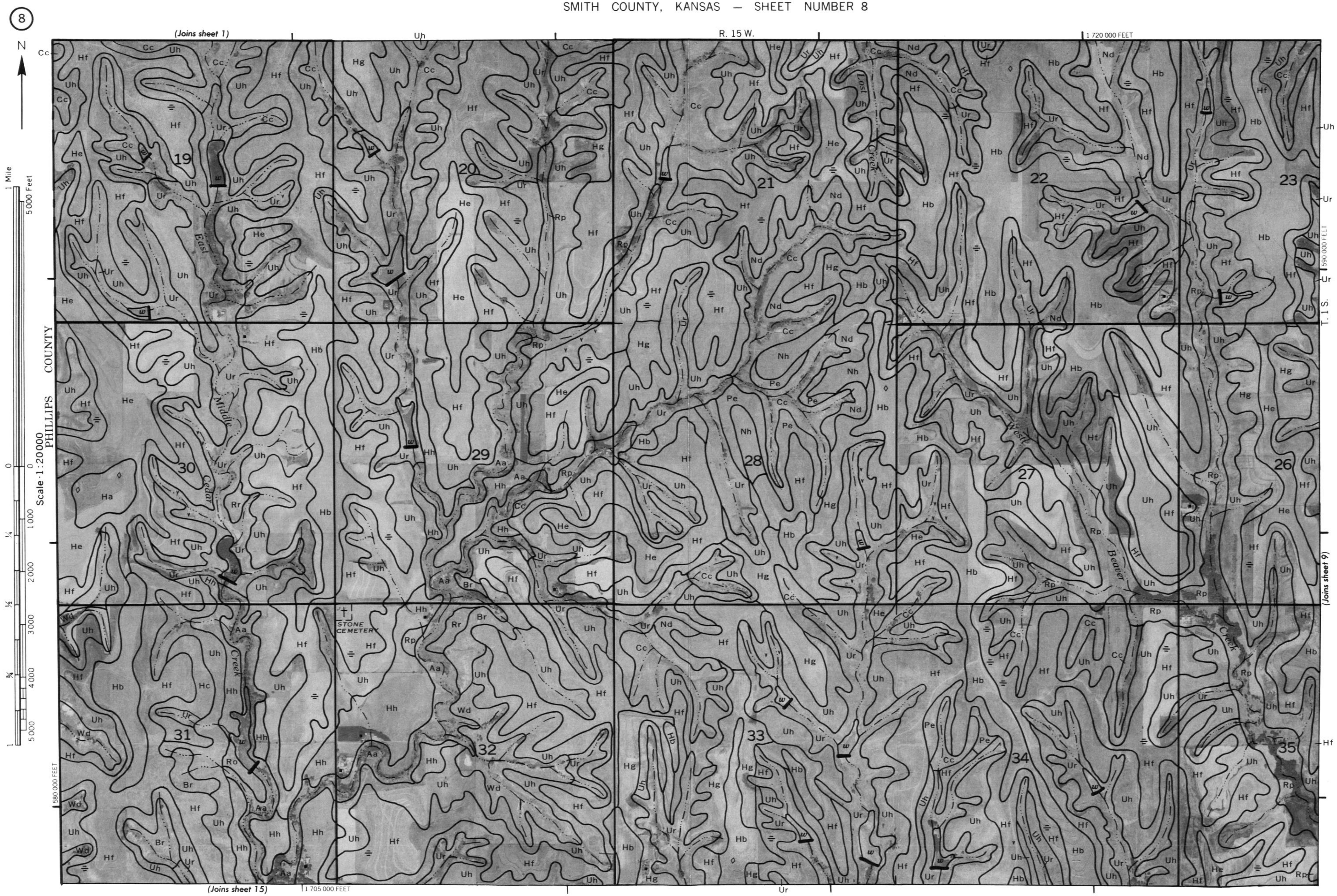




This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

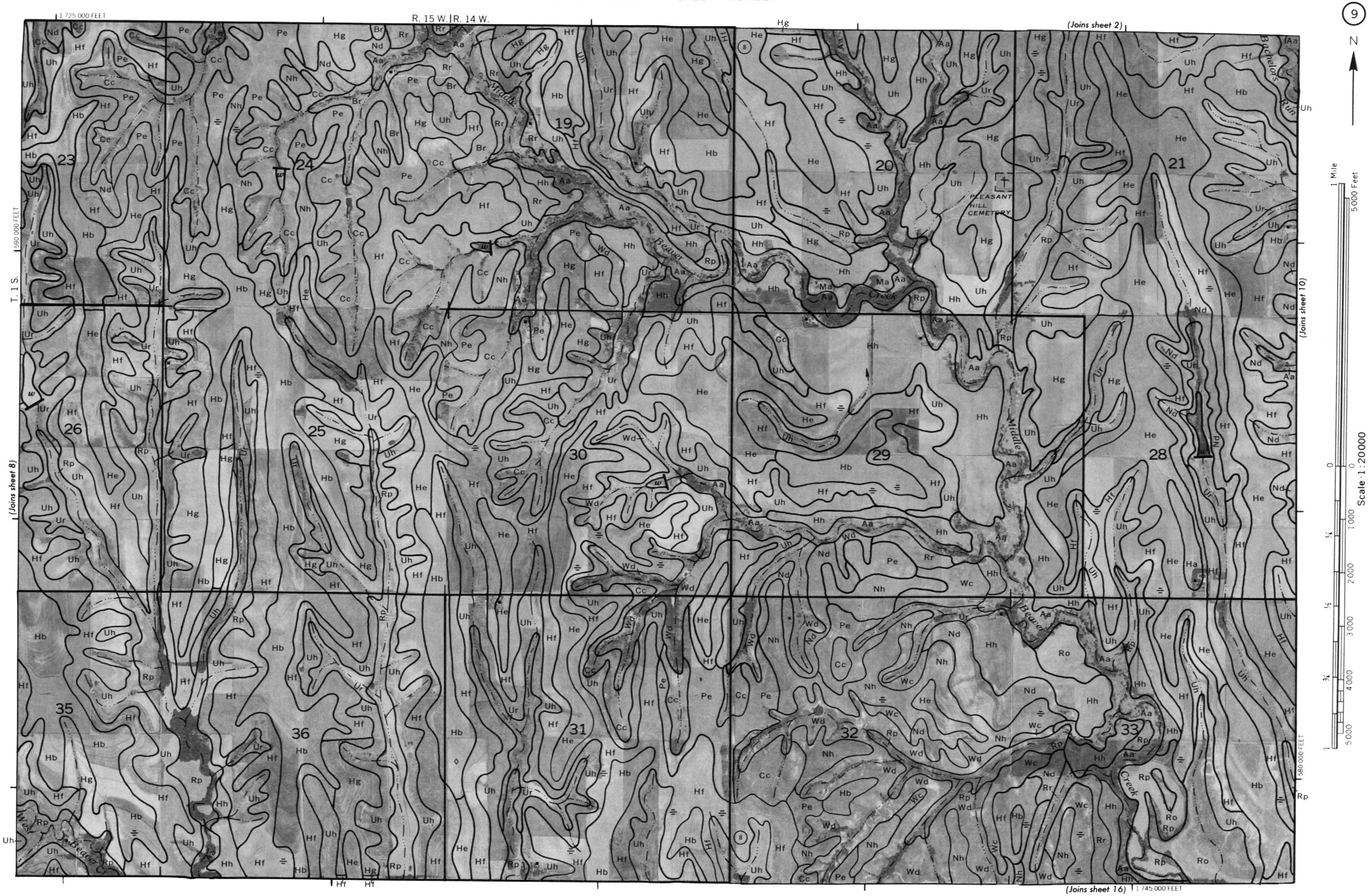


This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.



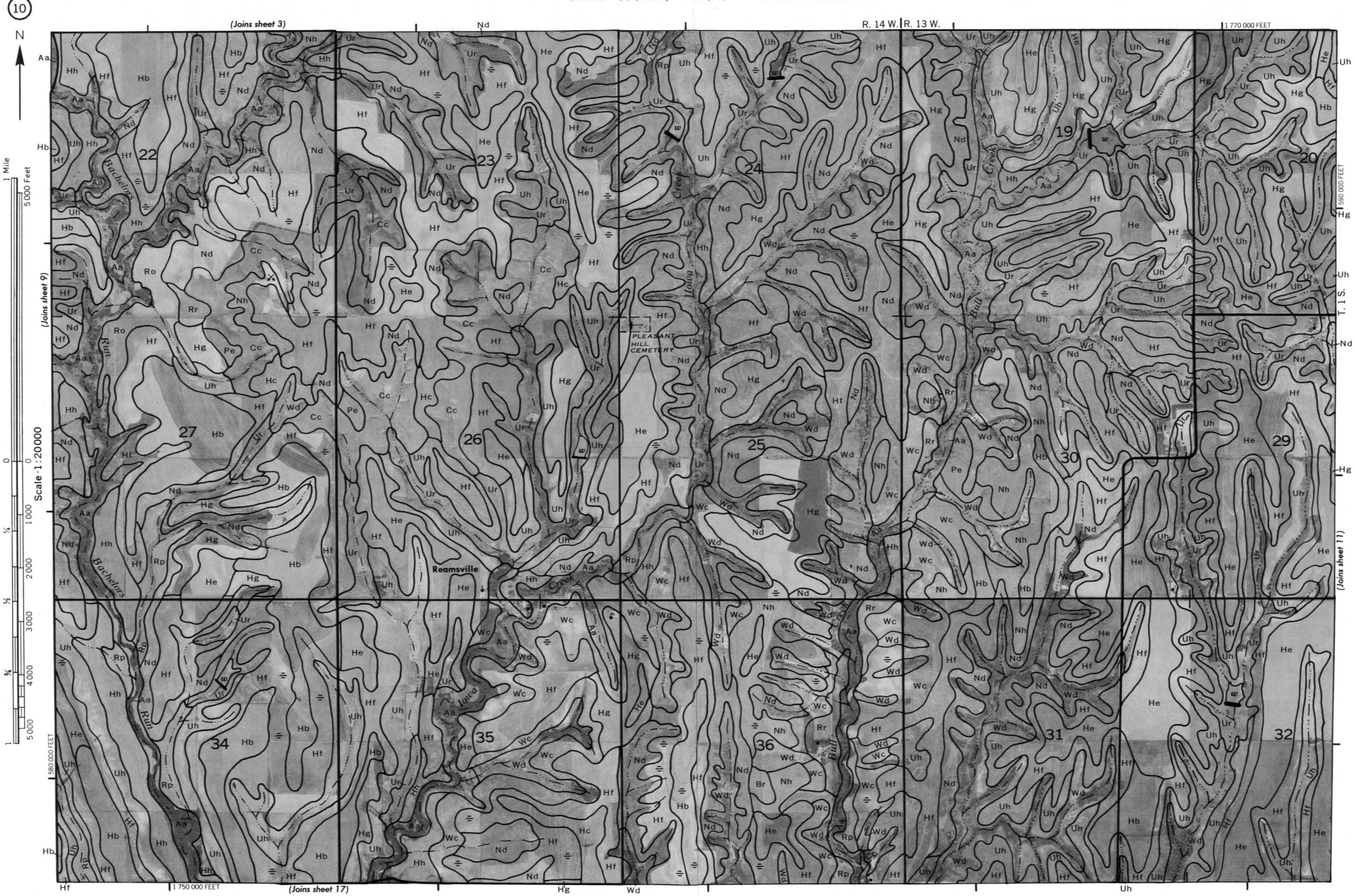
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 9

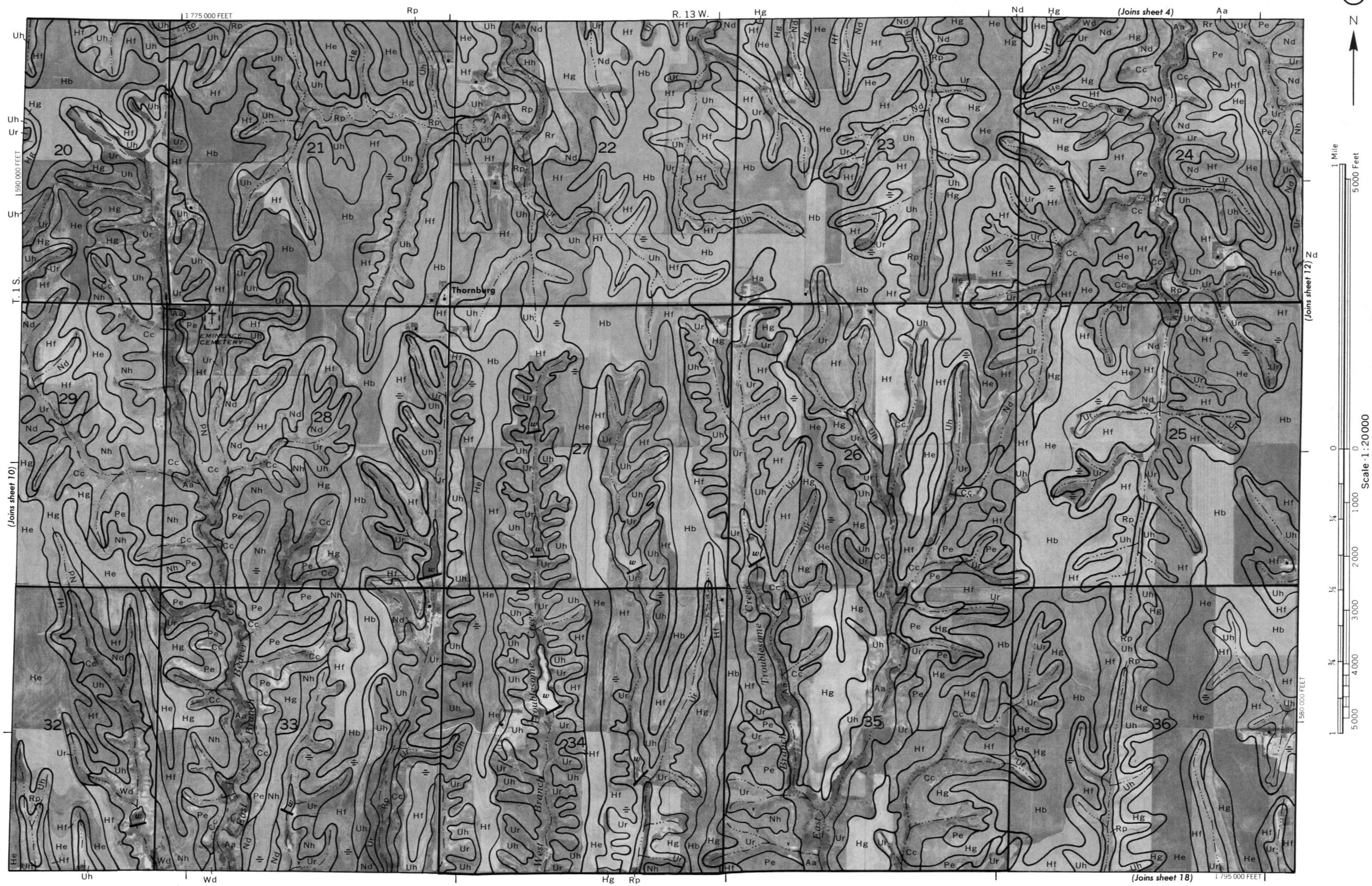


This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 10



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 12

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

13

N

1 Mile
5000 Feet
0
1000
2000
3000
4000
5000
0
¼
½
¾
1

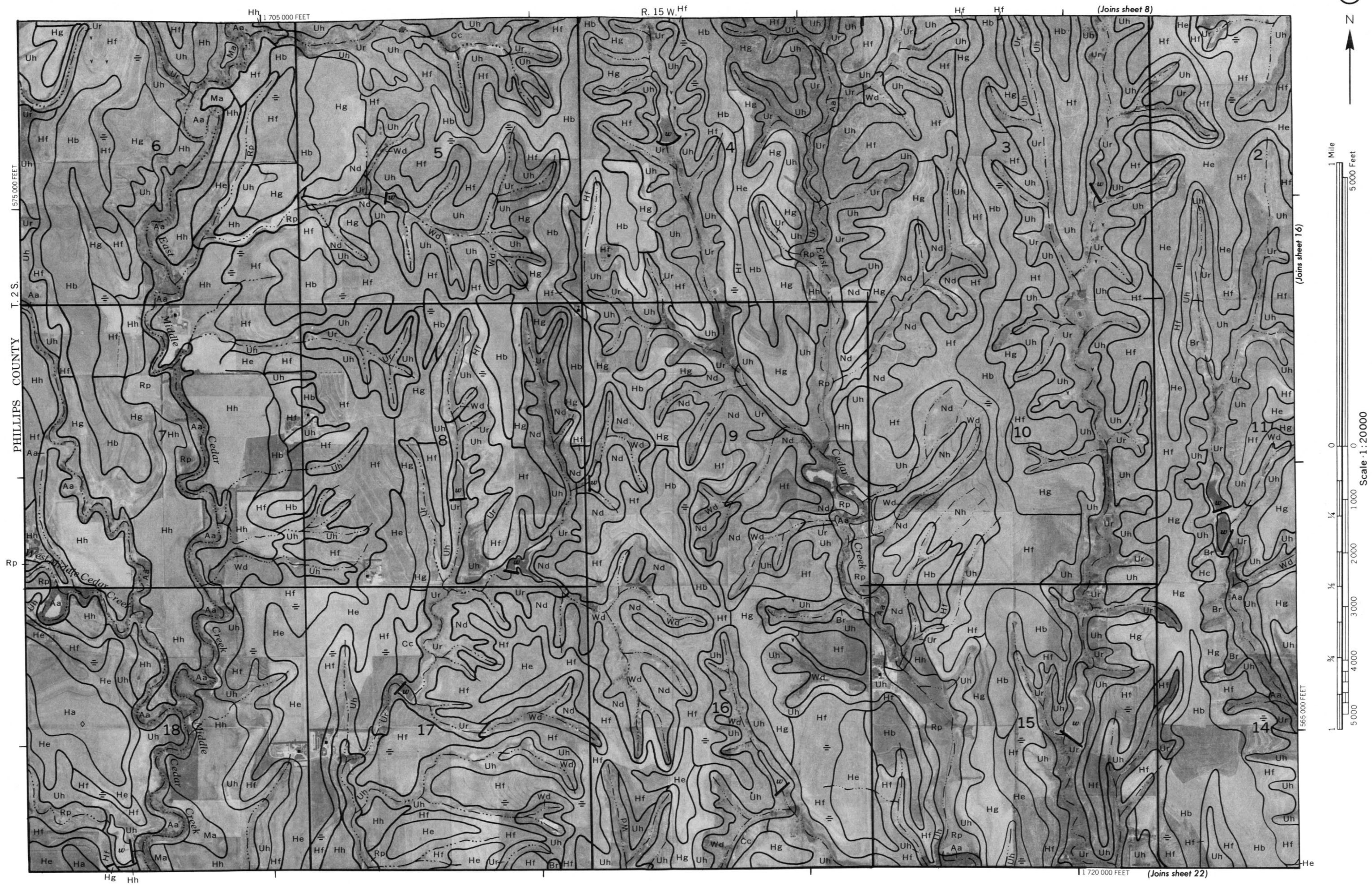
Scale 1:20000

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 14

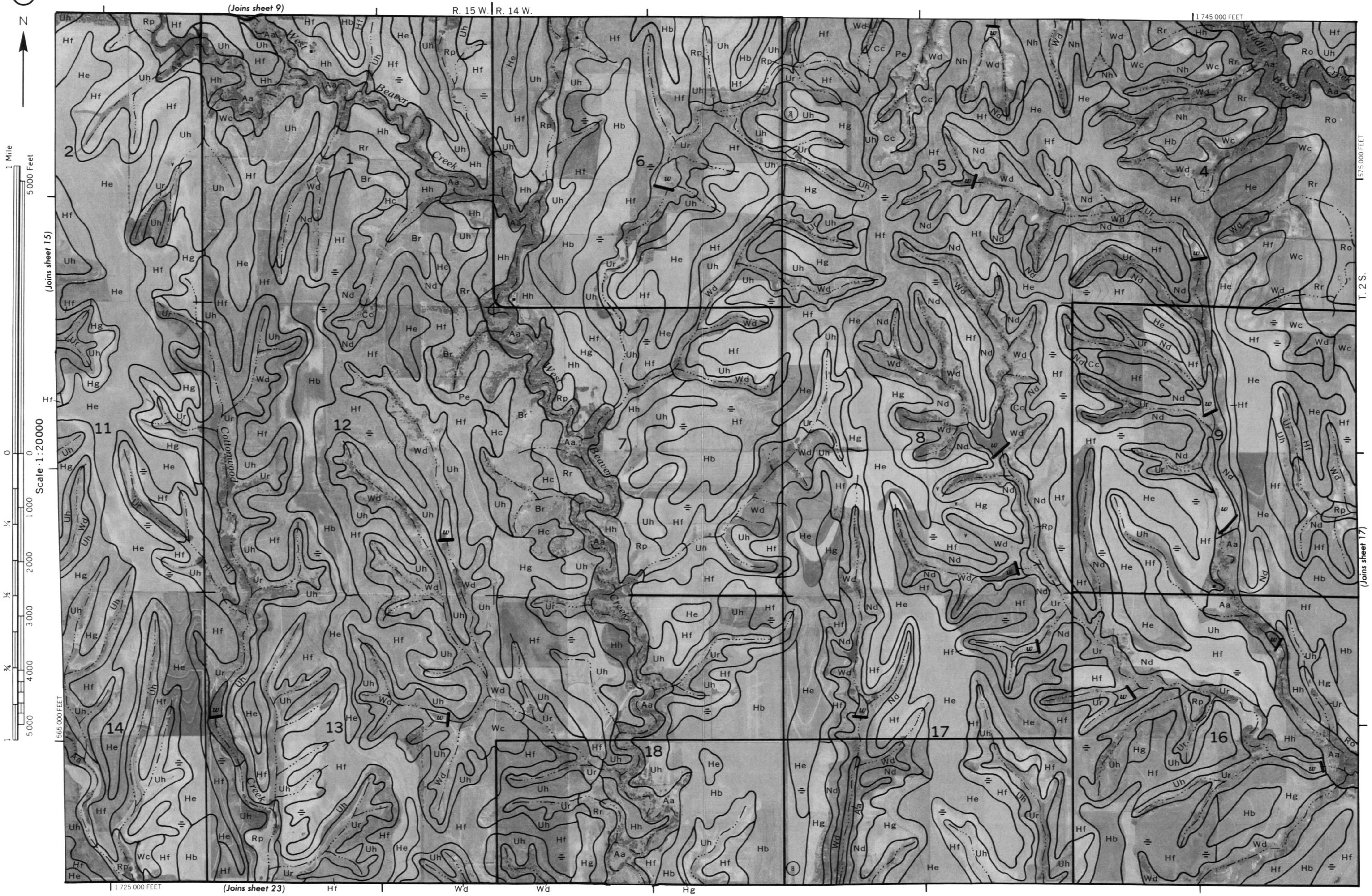
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 15

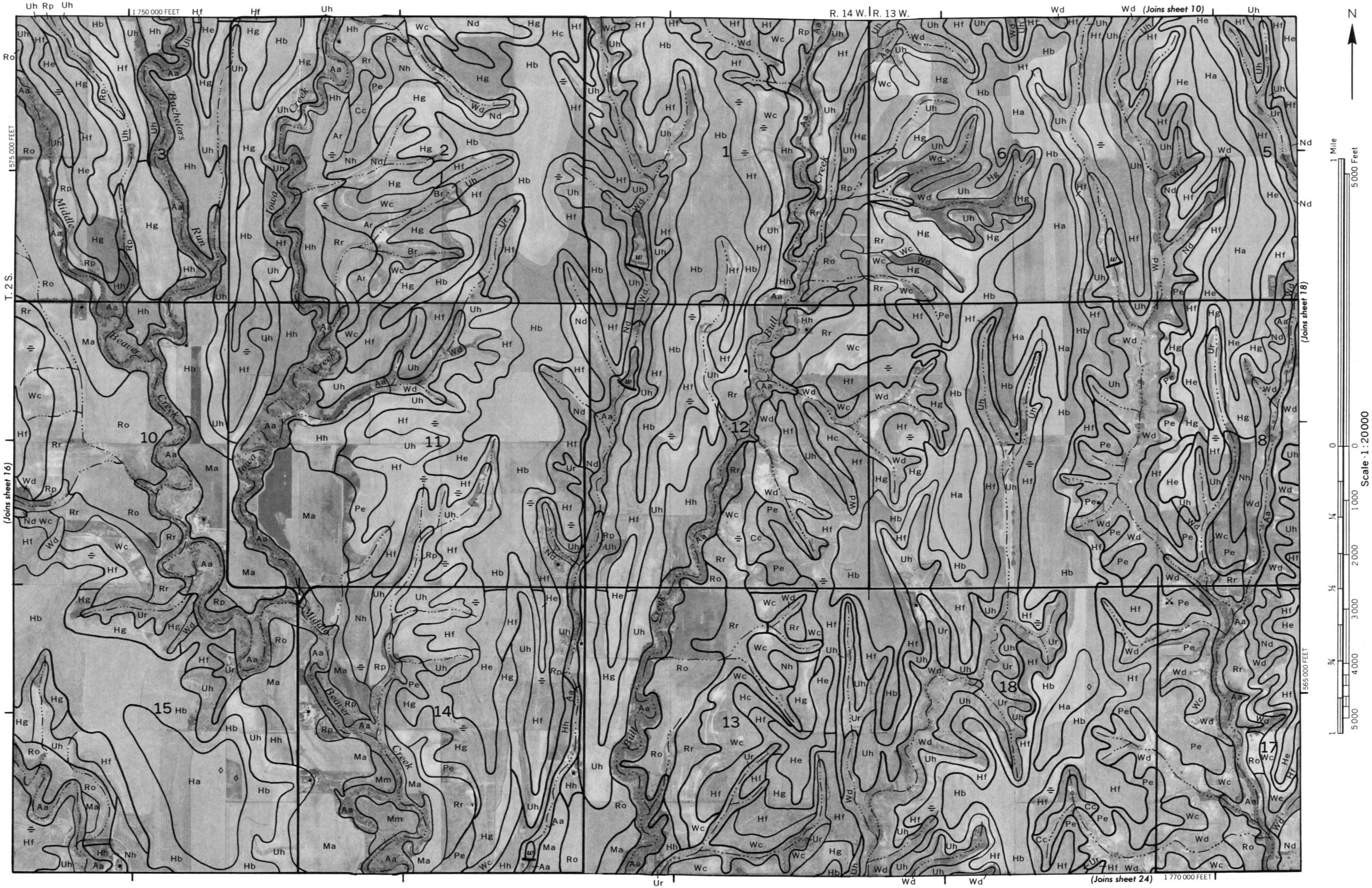


This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

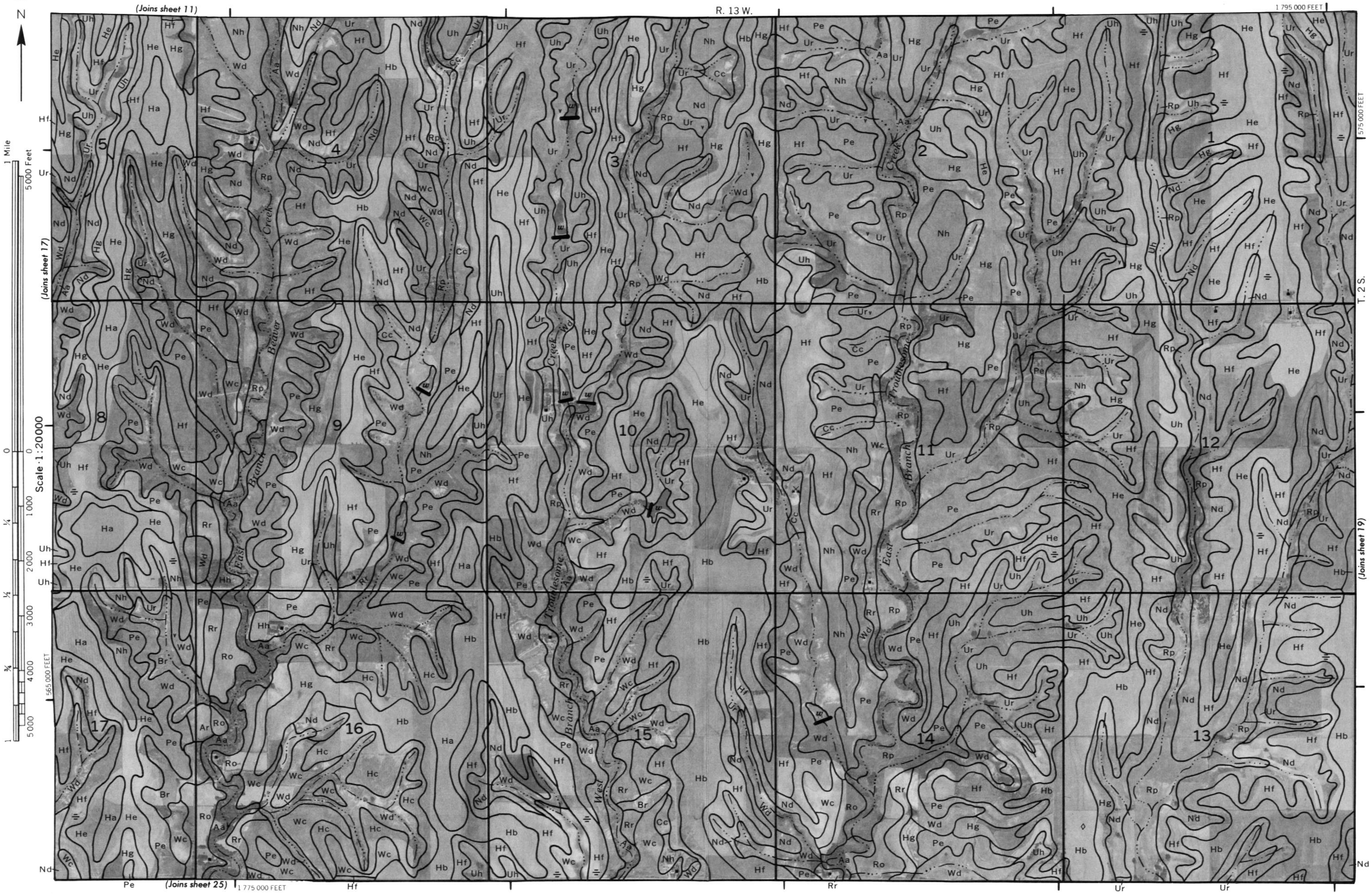
SMITH COUNTY, KANSAS — SHEET NUMBER 16



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

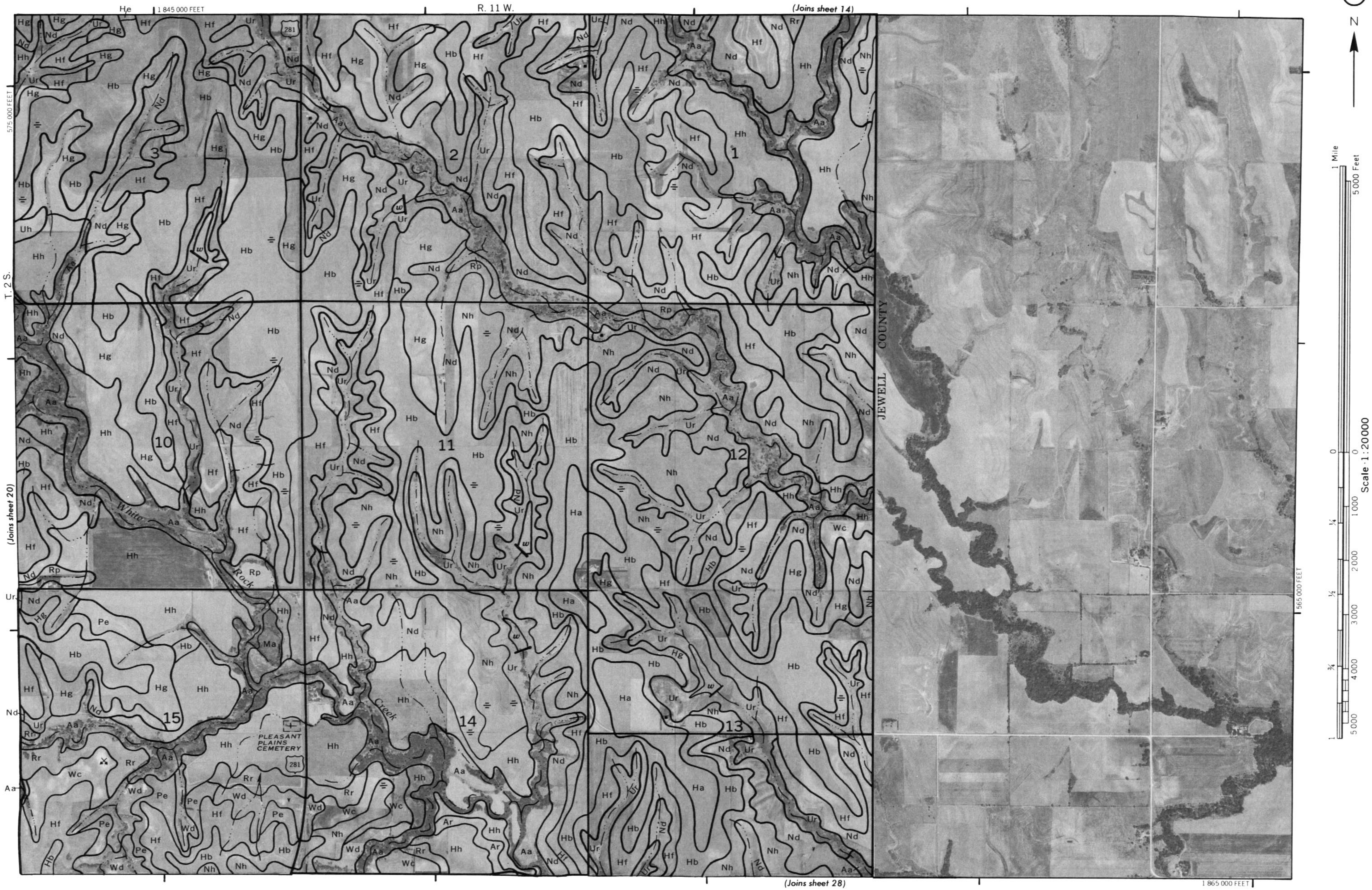


This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 21



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 22

N

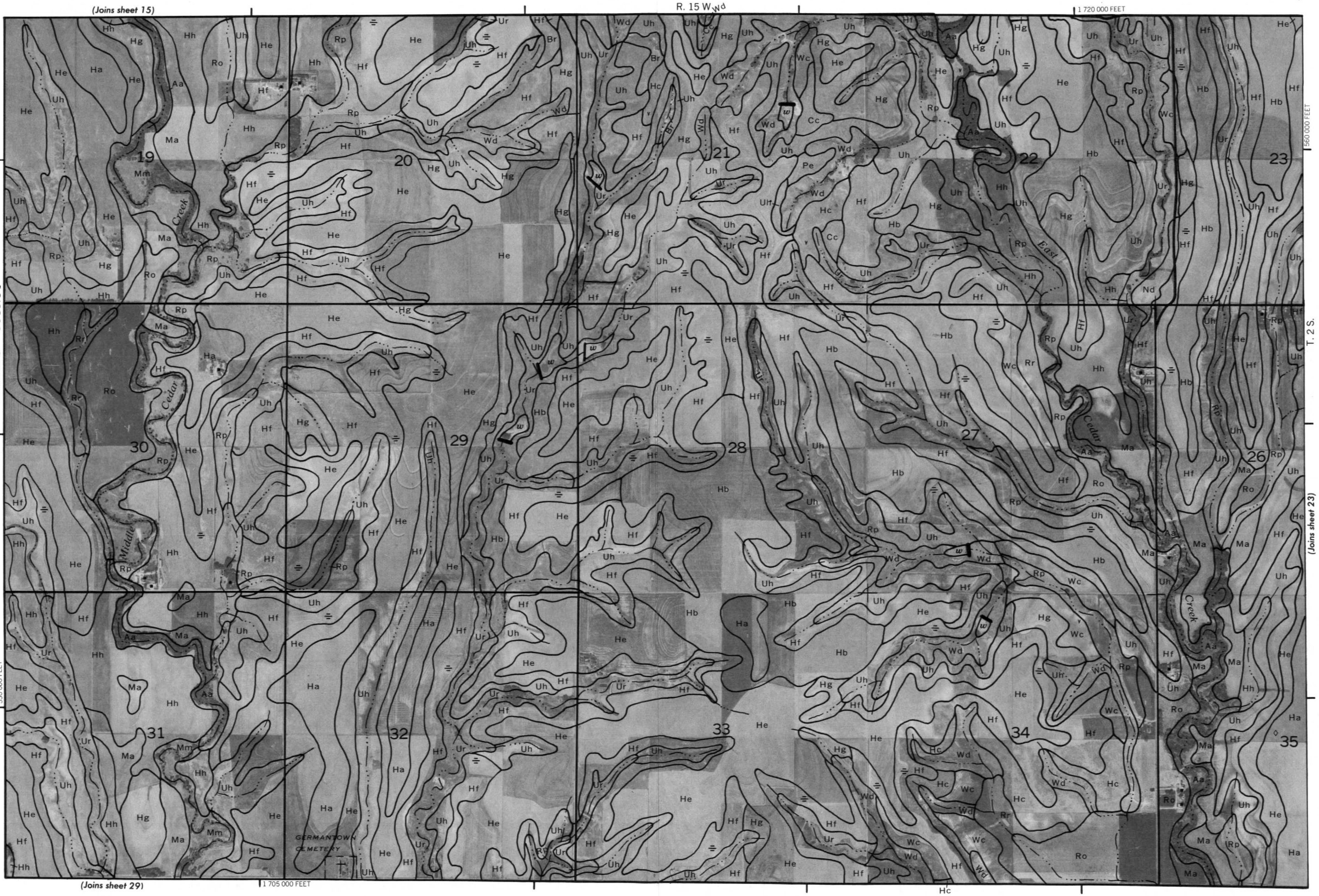
1 Mile

5000 Feet

Scale 1:20000

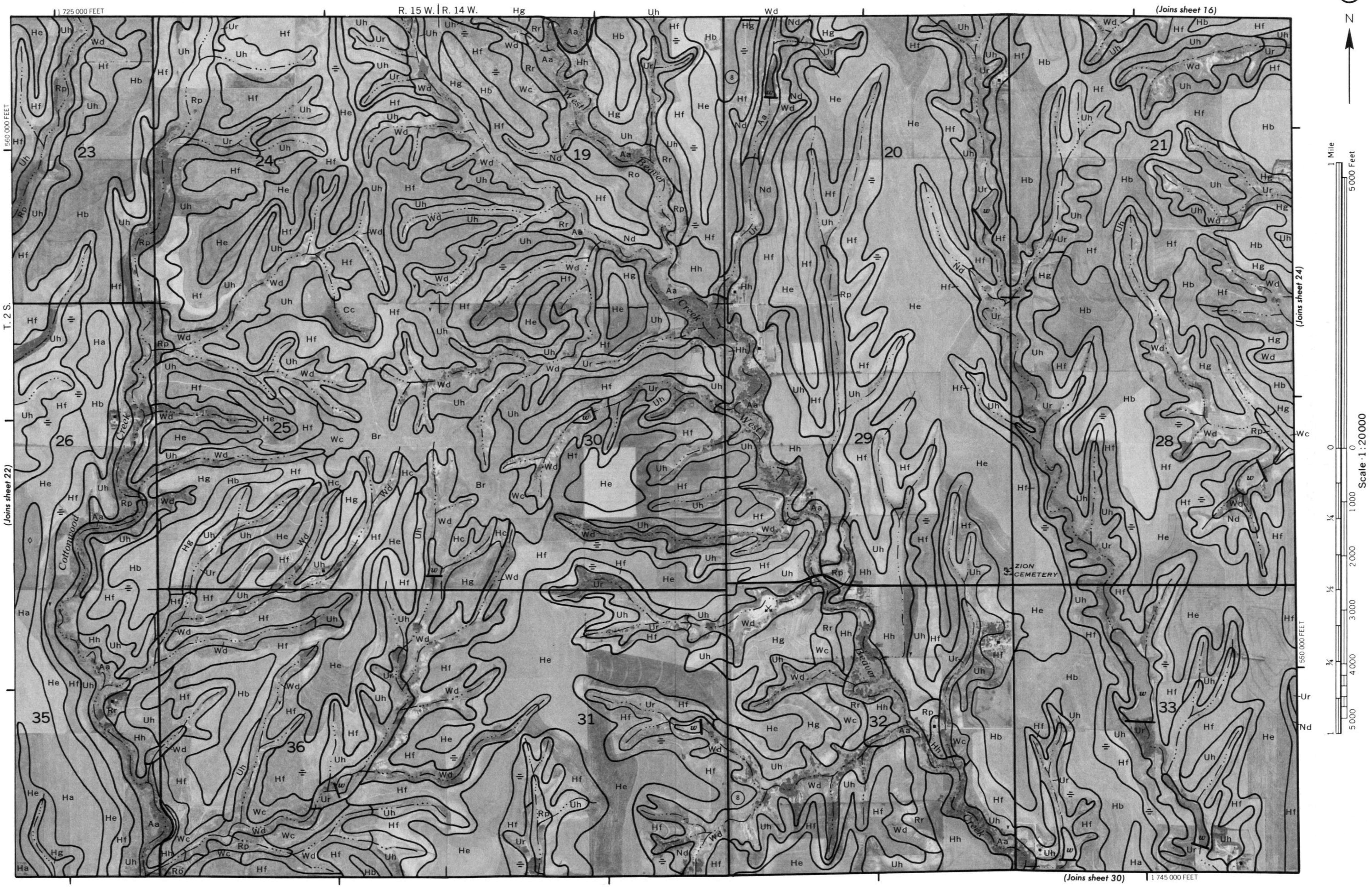
0 ¼ ½ ¾ 1

0 1000 2000 3000 4000 5000



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 23



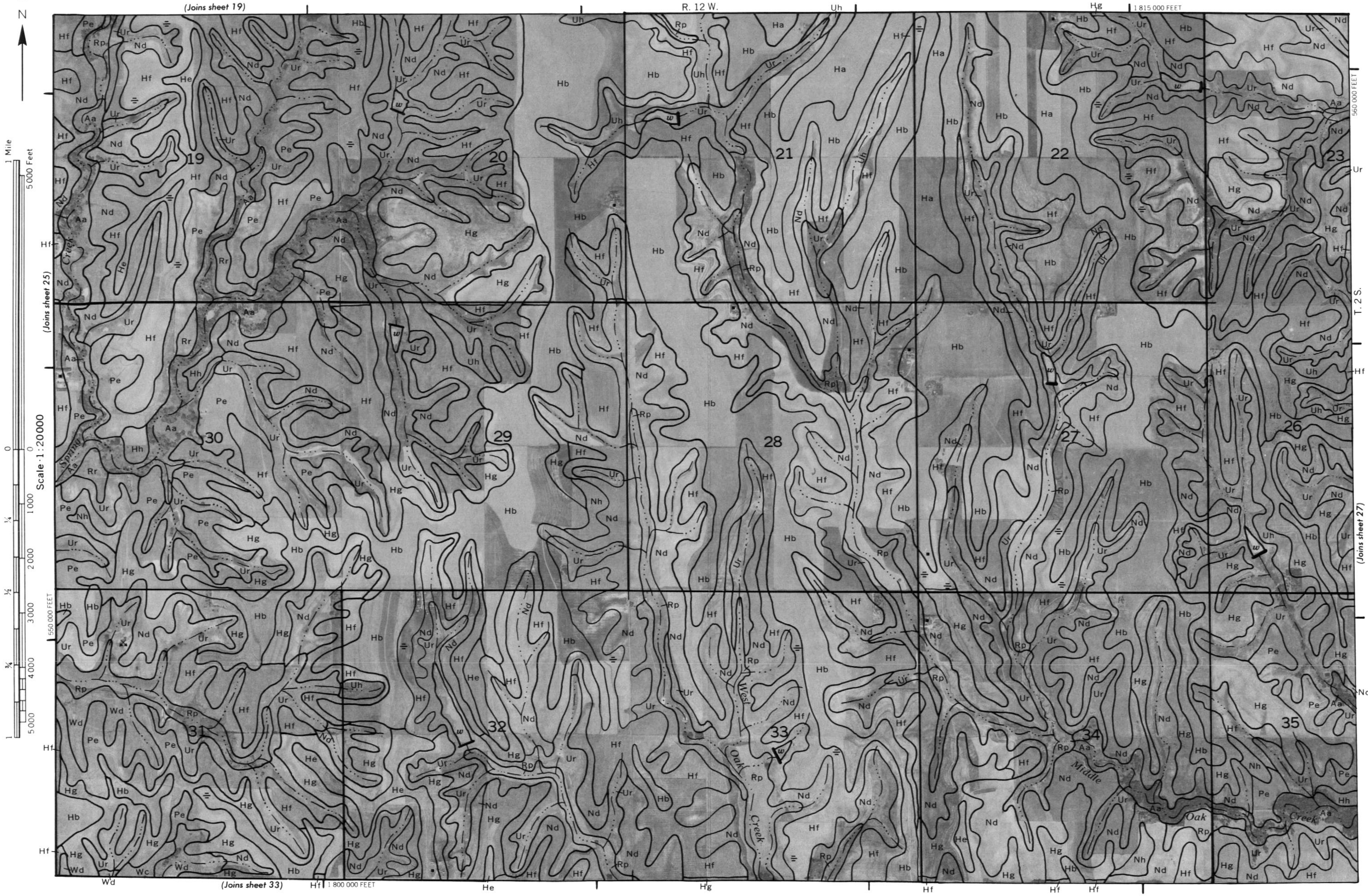
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 24

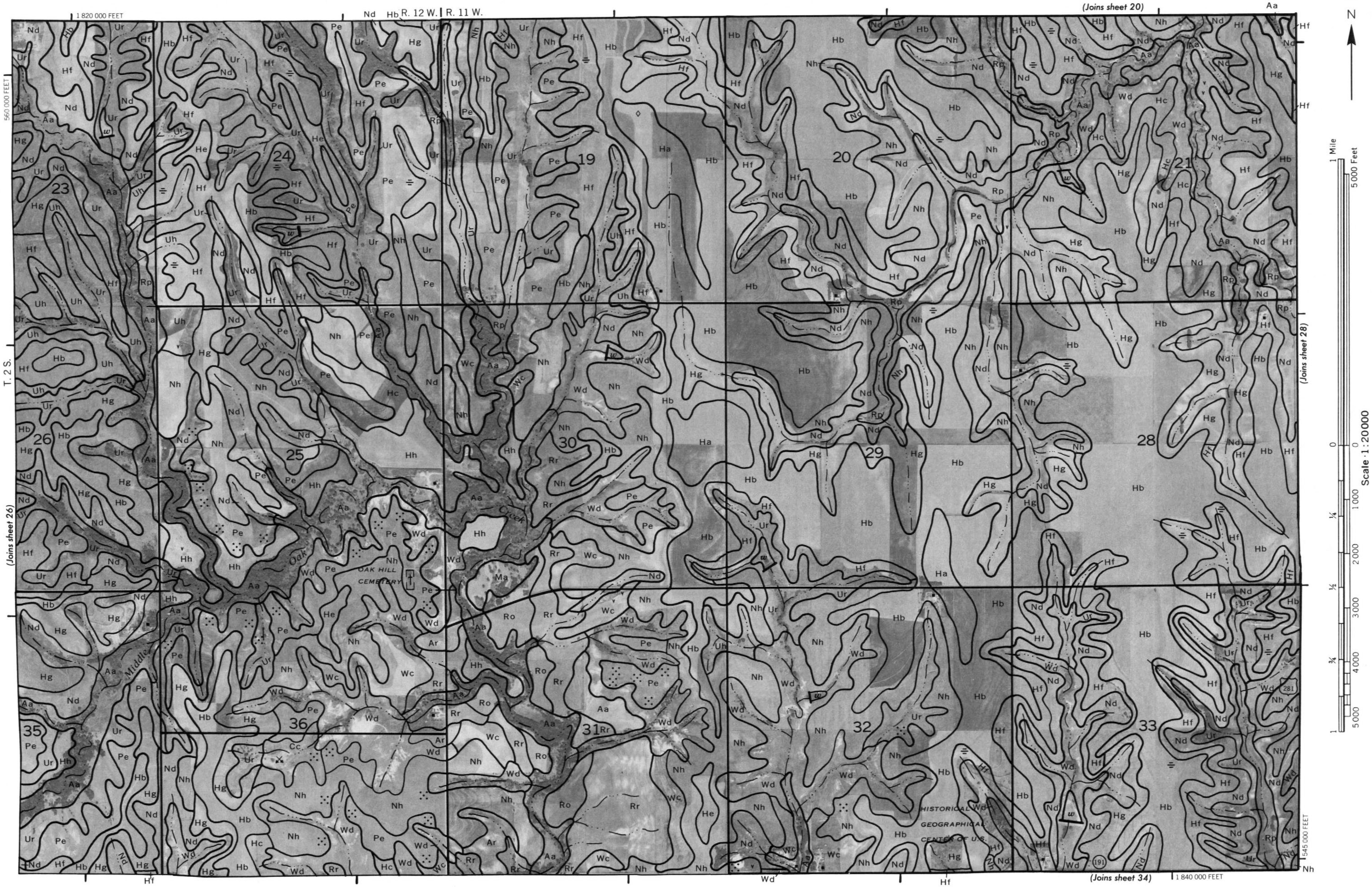
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 26

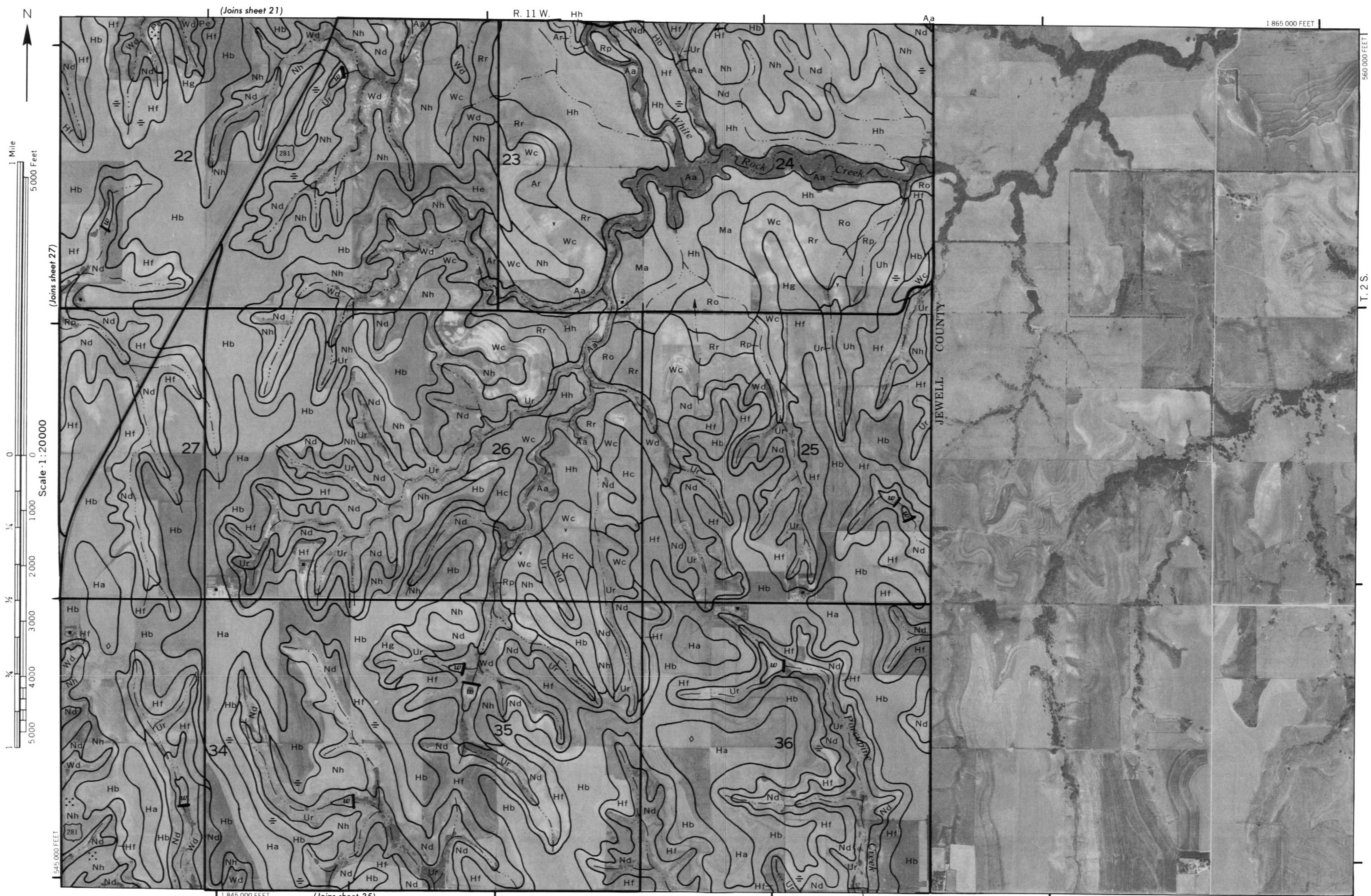


This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 28

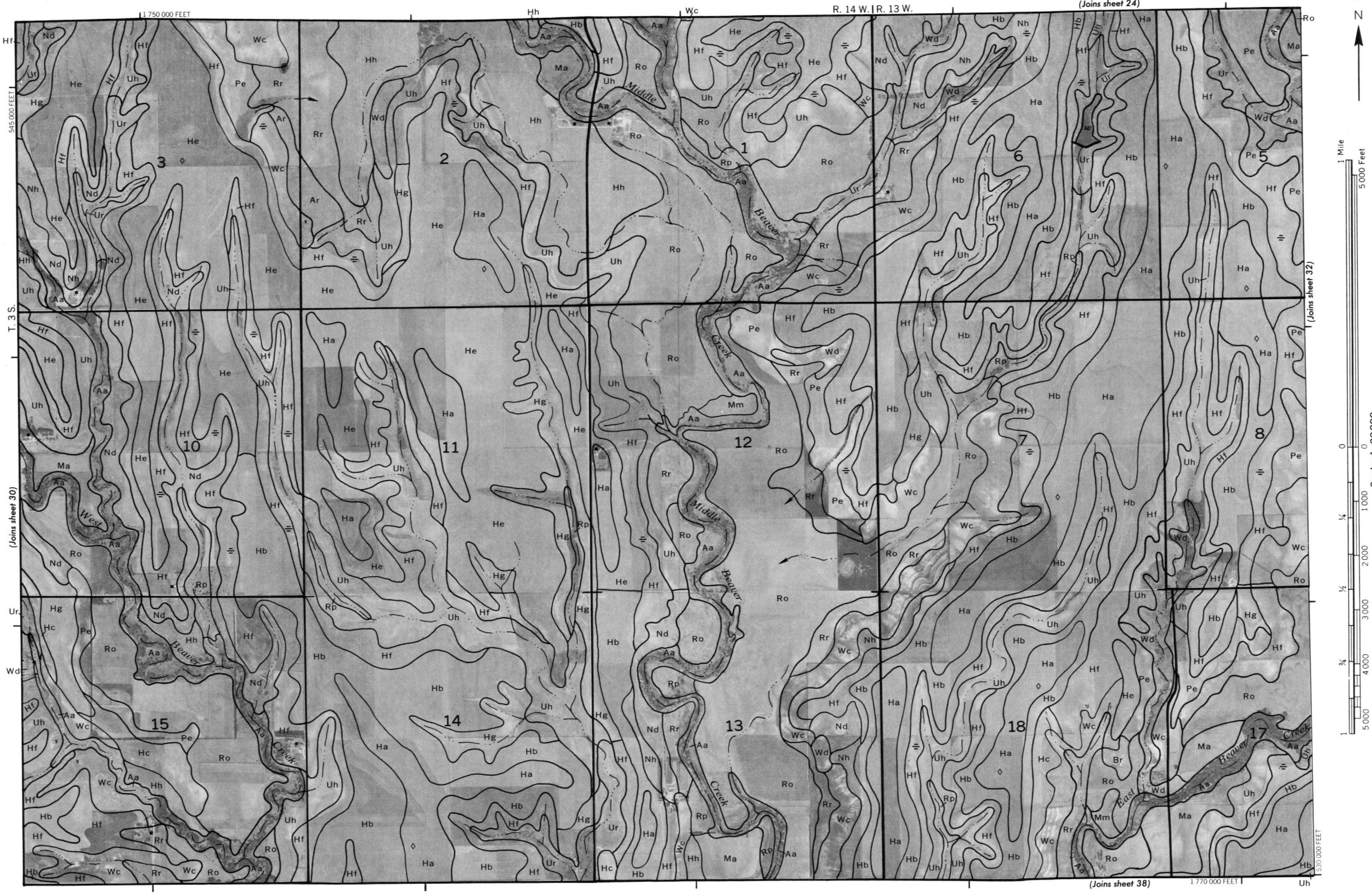


This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

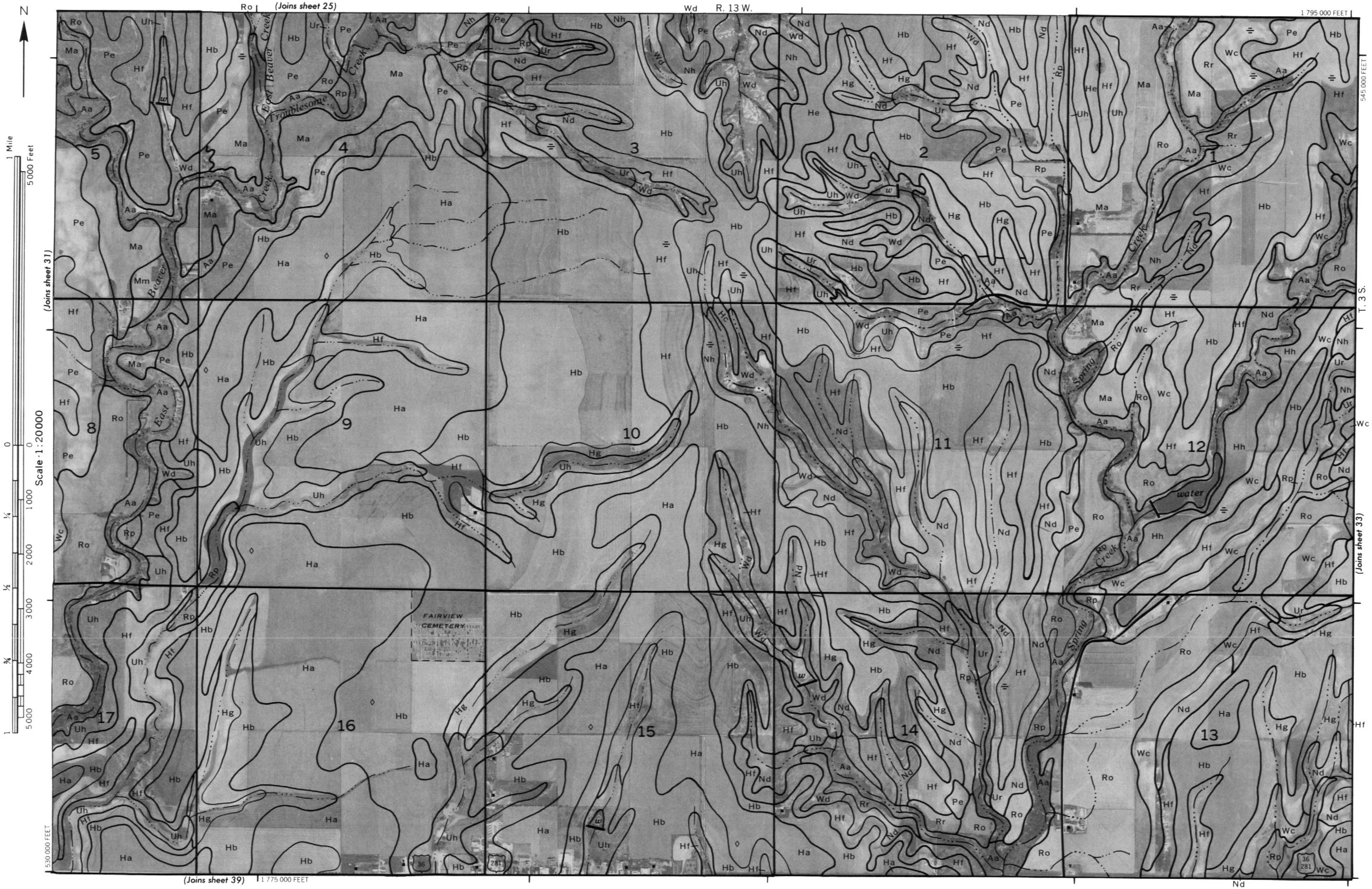
SMITH COUNTY, KANSAS — SHEET NUMBER 30

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

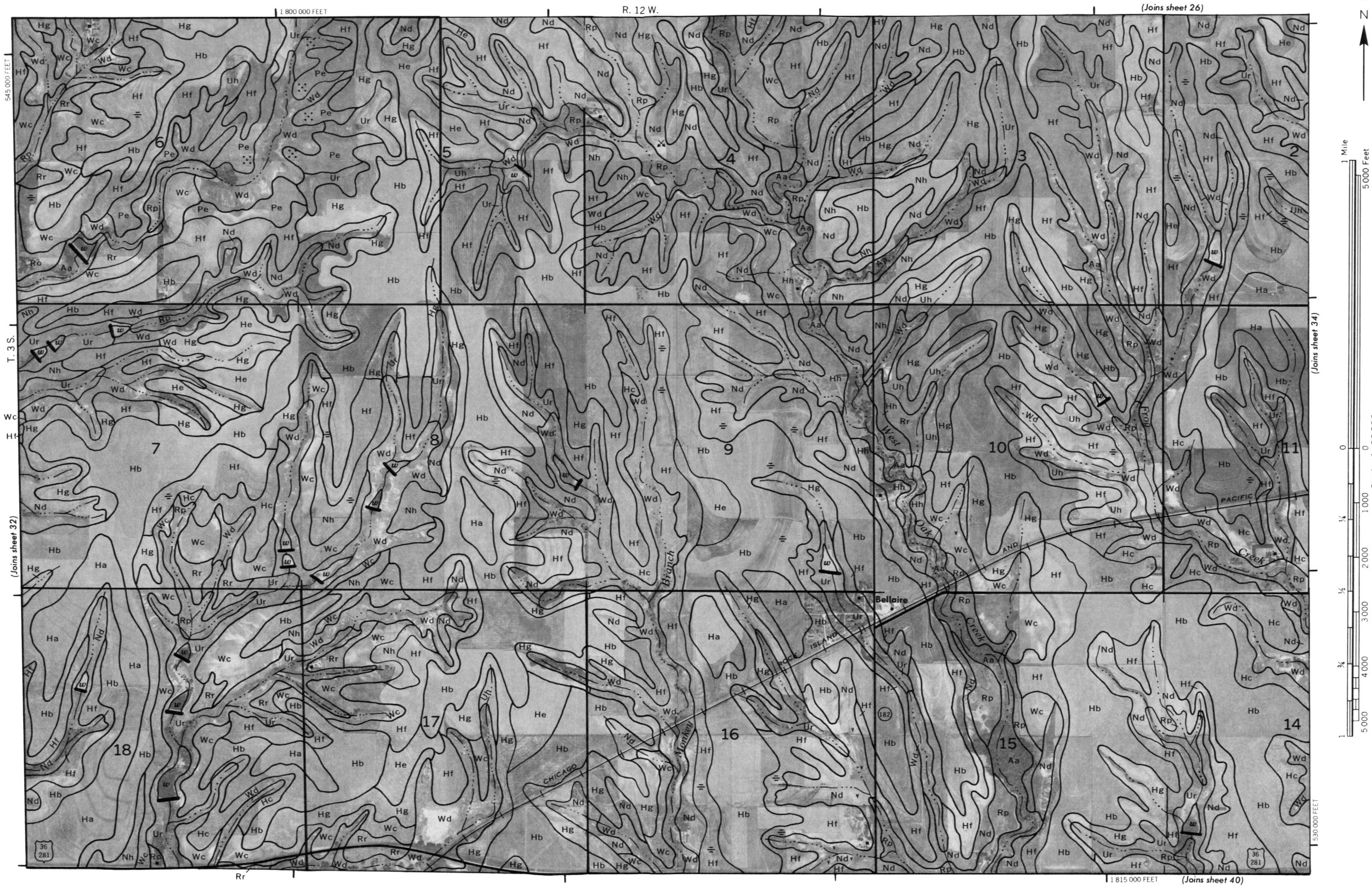


This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 32



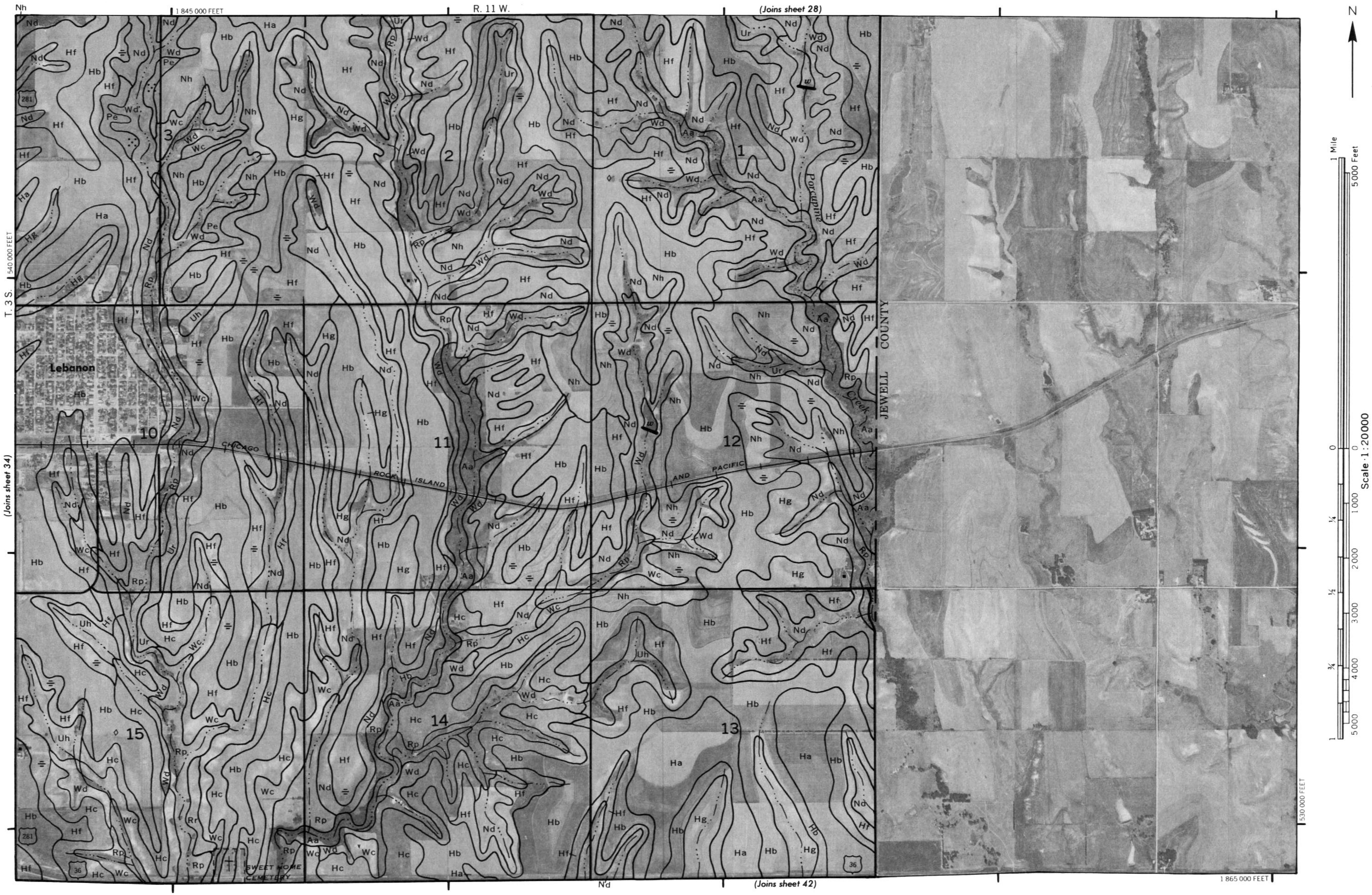
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 34

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

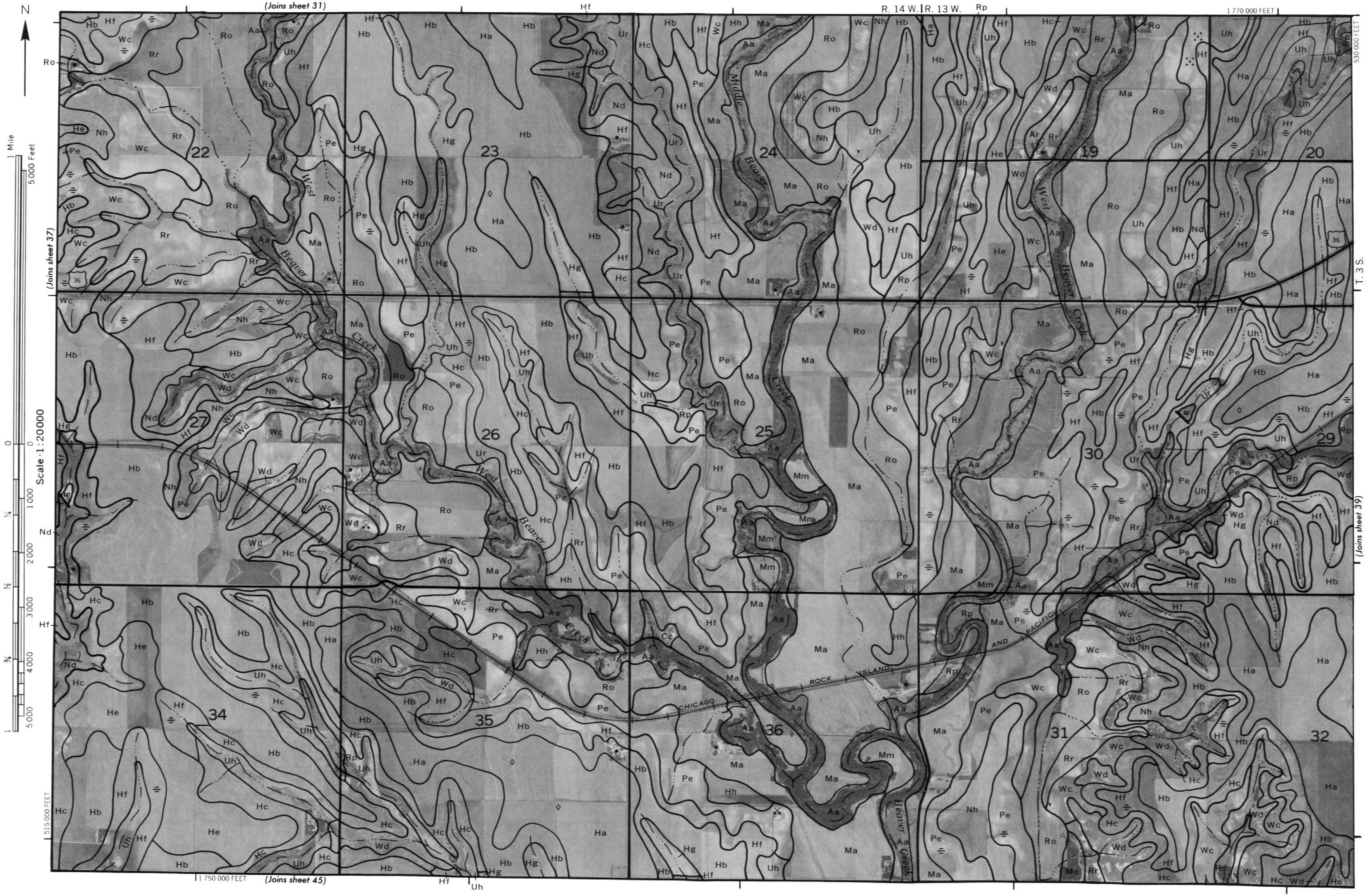


This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

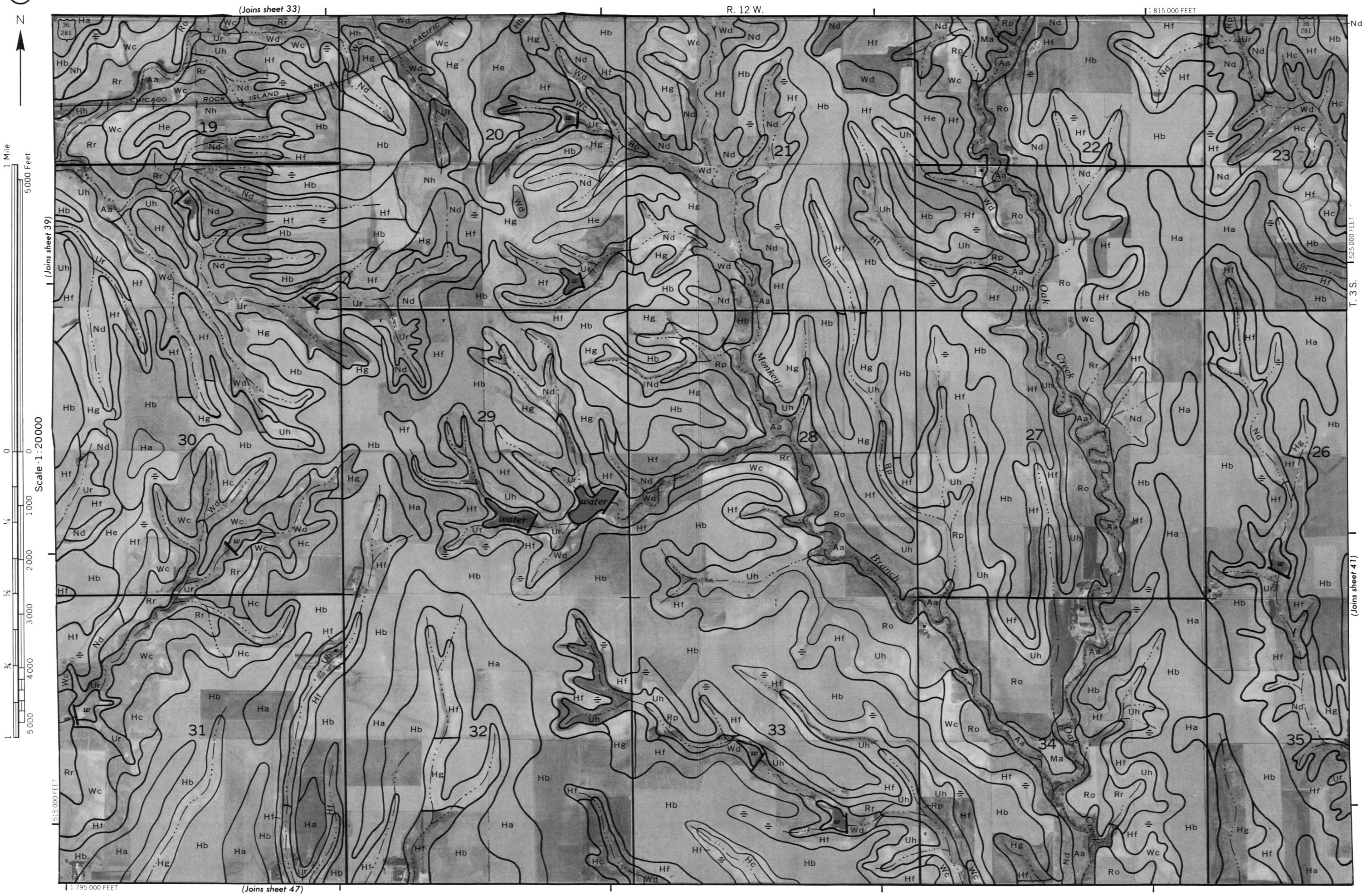
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 38

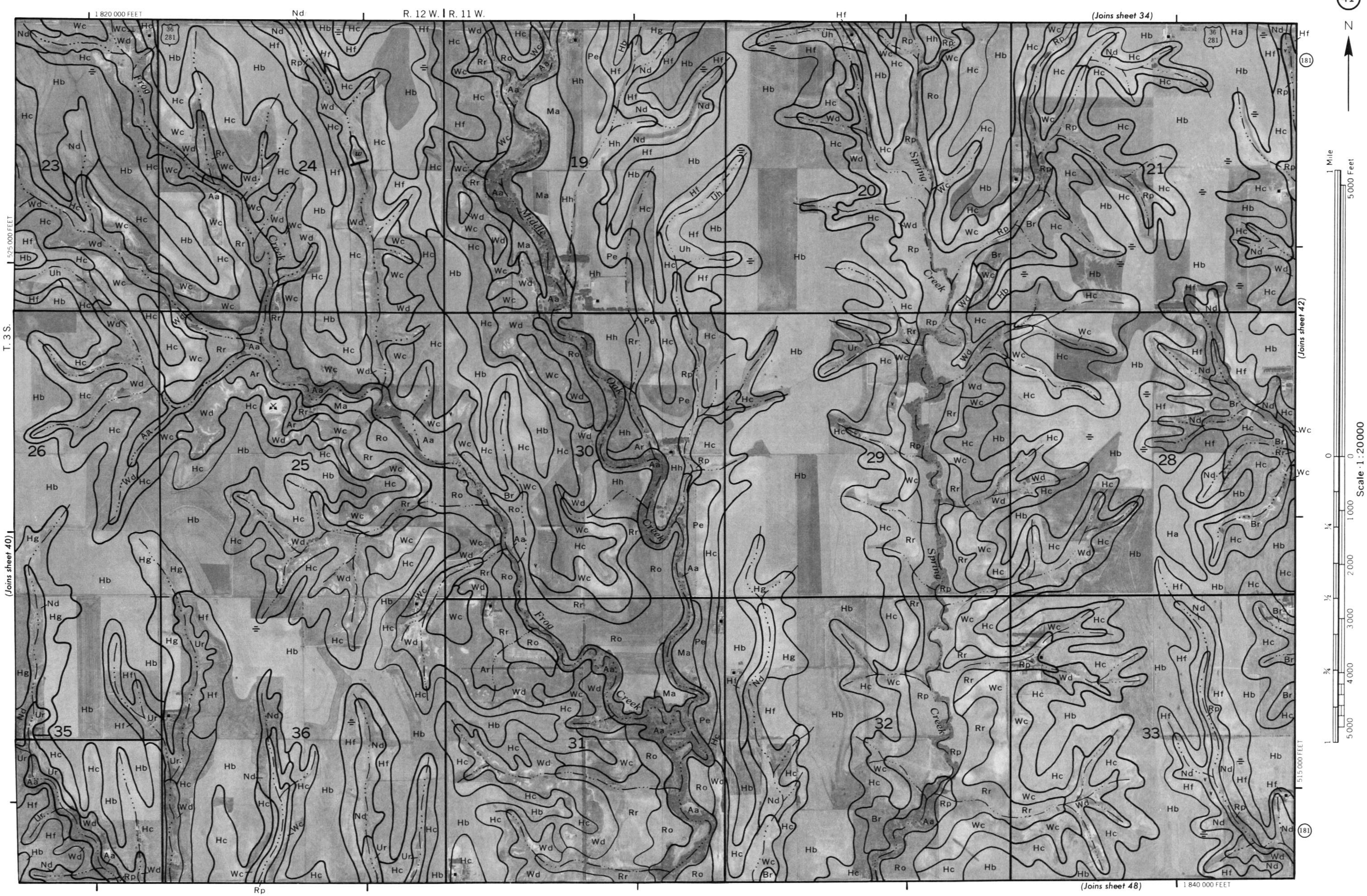


This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

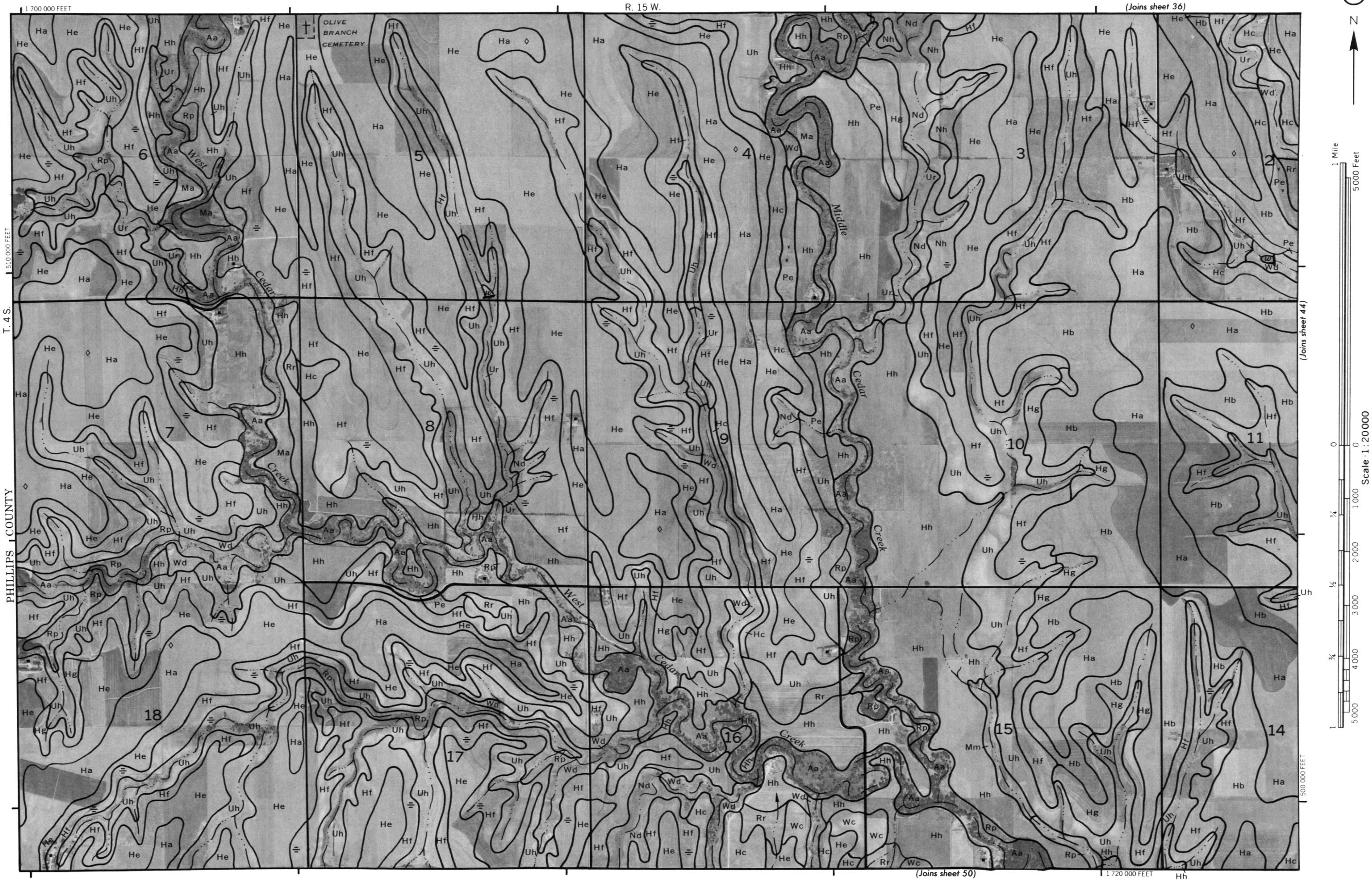


This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.


41
N
R. 12 W.
R. 11 W.
T. 3 S.
1 820 000 FEET
525 000 FEET
515 000 FEET
1 840 000 FEET
(Joins sheet 34)
(Joins sheet 42)
(Joins sheet 48)
(Joins sheet 40)
Middle Creek
Oak Creek
Frog Creek
Spring Creek
1 Mile
5000 Feet
Scale 1:20000

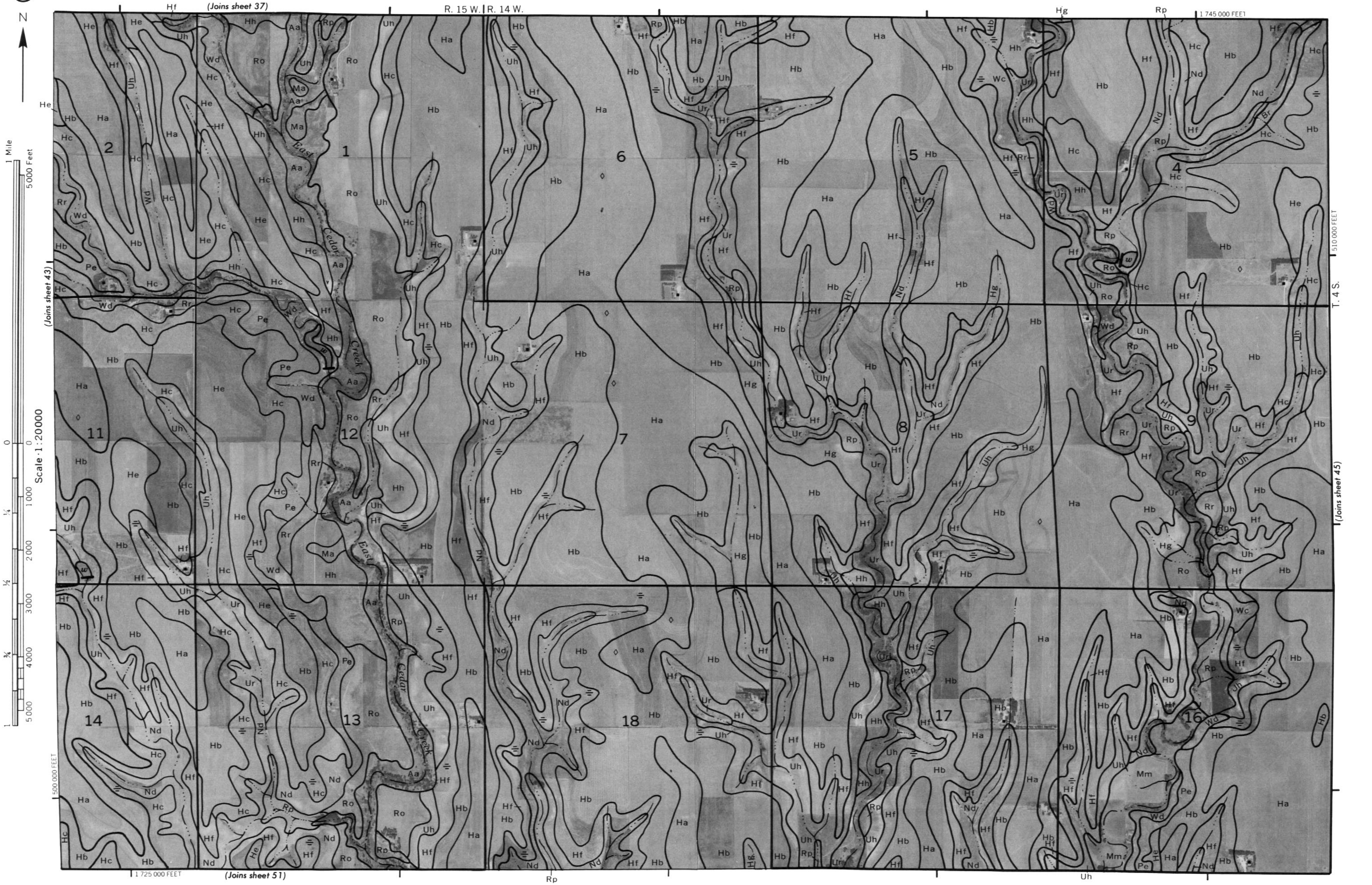
SMITH COUNTY, KANSAS — SHEET NUMBER 42

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

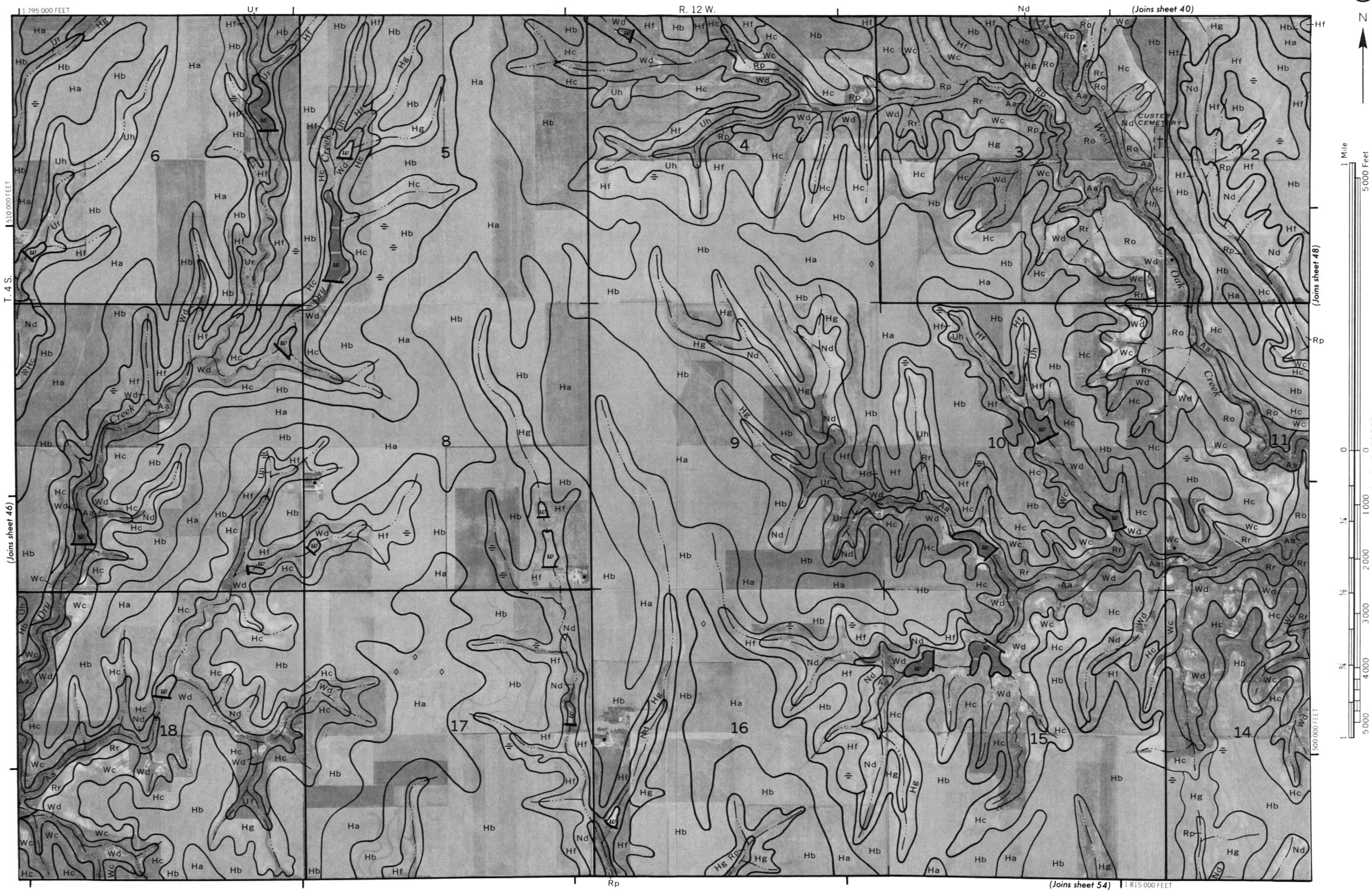
SMITH COUNTY, KANSAS — SHEET NUMBER 44



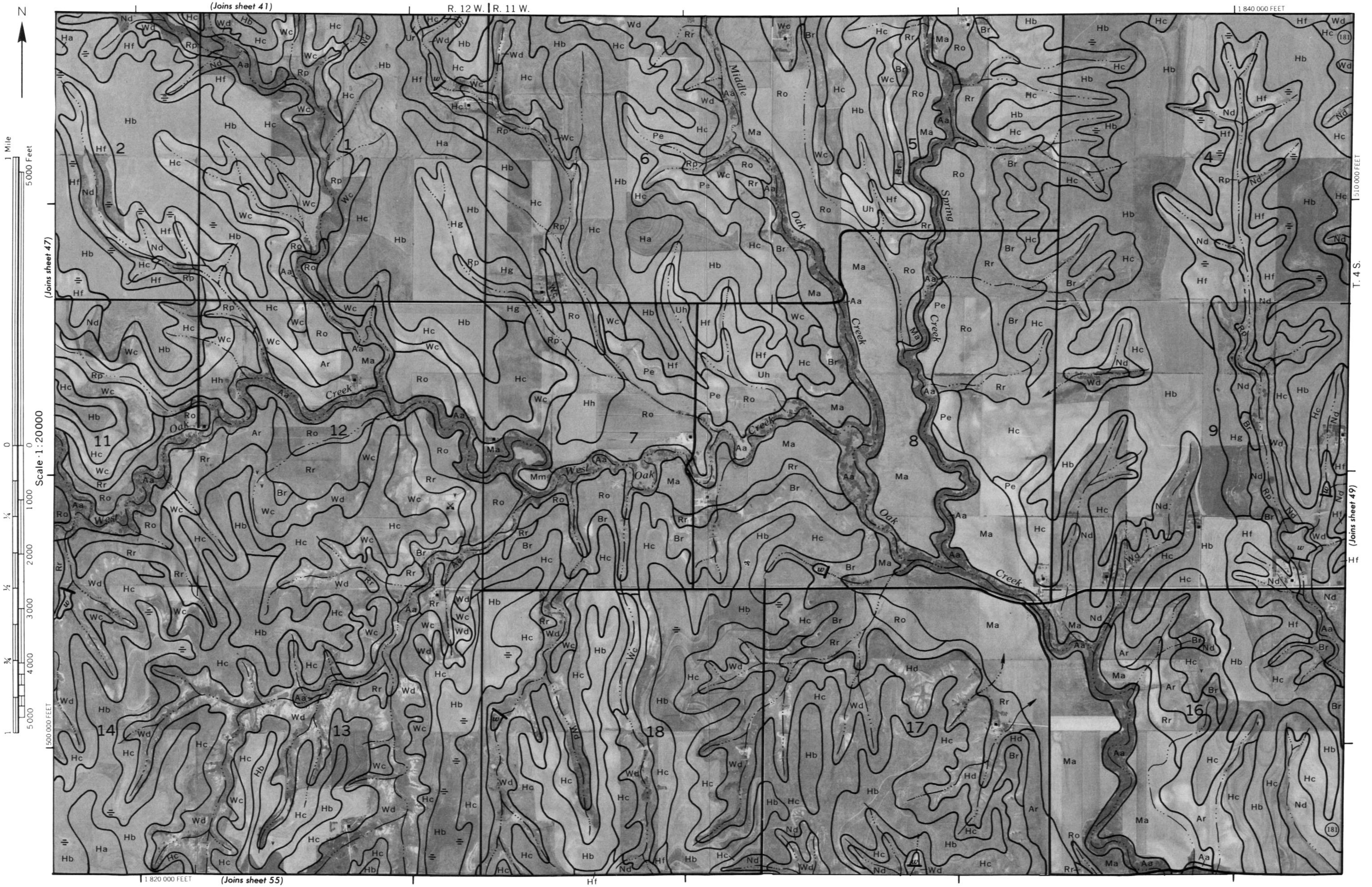
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

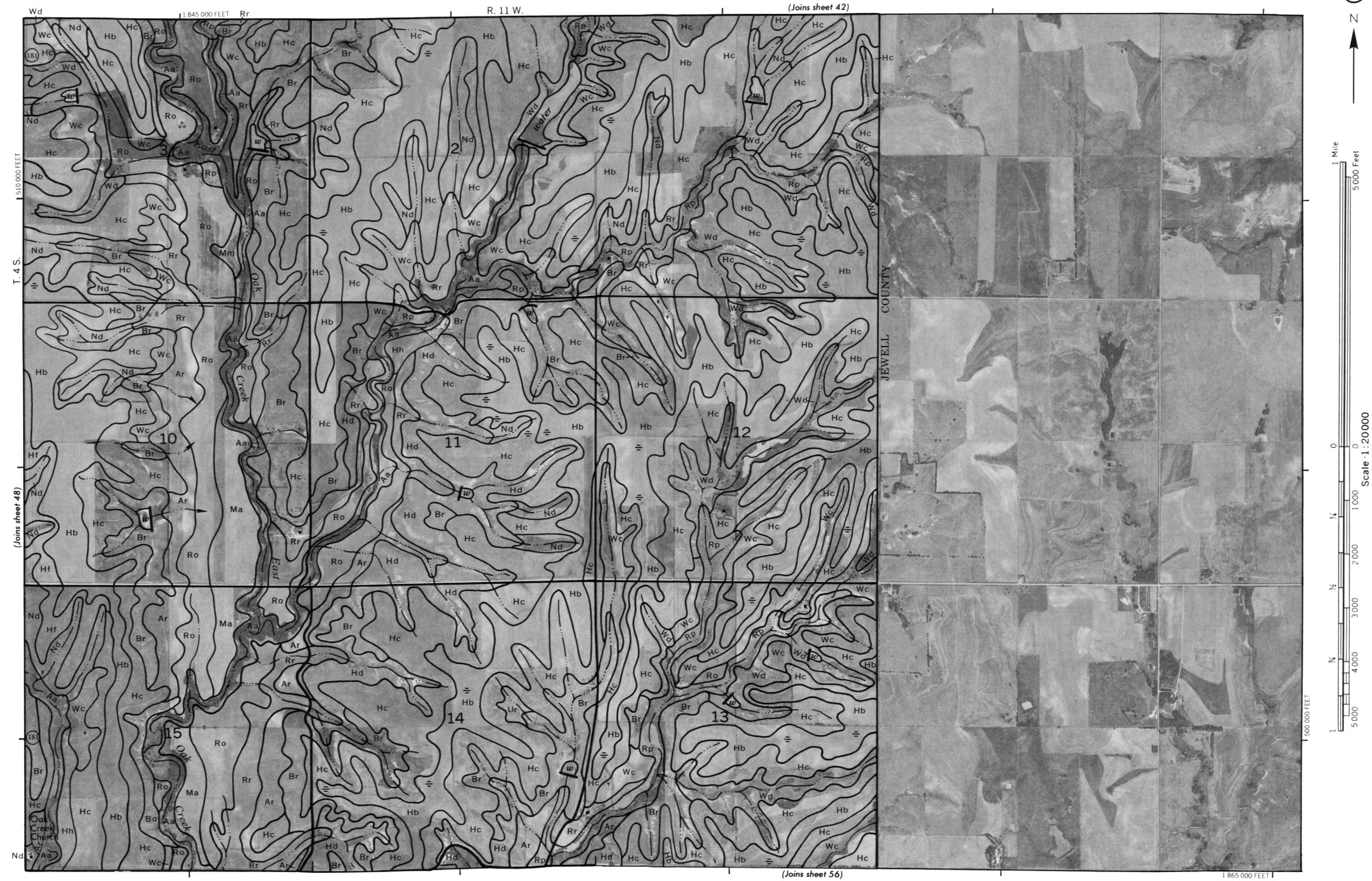
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.


47
R. 12 W.
T. 4 S.
(Joins sheet 40)
(Joins sheet 48)
(Joins sheet 54)
(Joins sheet 46)
1 795 000 FEET
1 815 000 FEET
510 000 FEET
500 000 FEET
N
Scale 1:20000
1 Mile
5000 Feet
CUSTER CEMETERY
Dry Creek
West Oak Creek

SMITH COUNTY, KANSAS — SHEET NUMBER 48



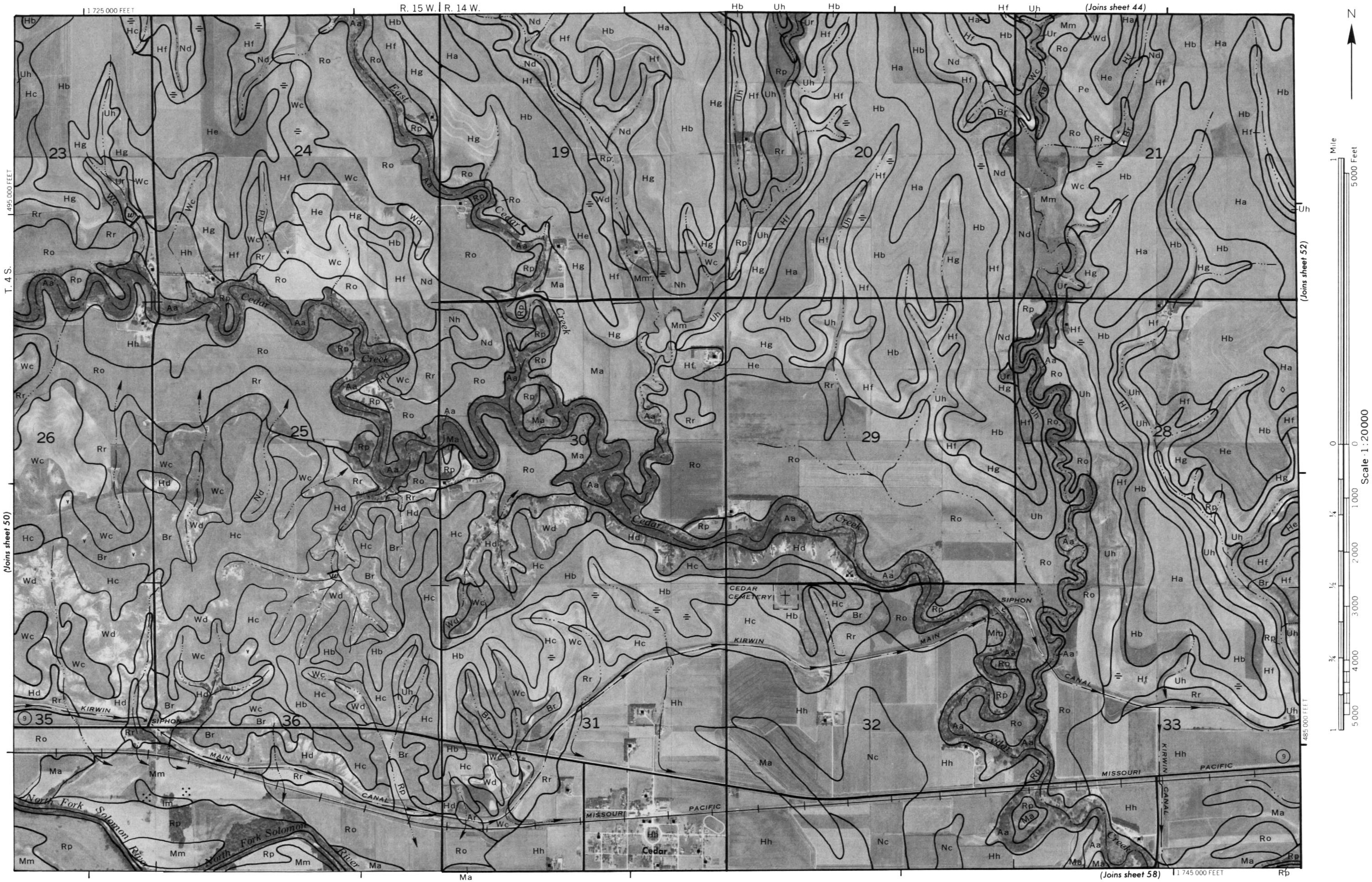
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.



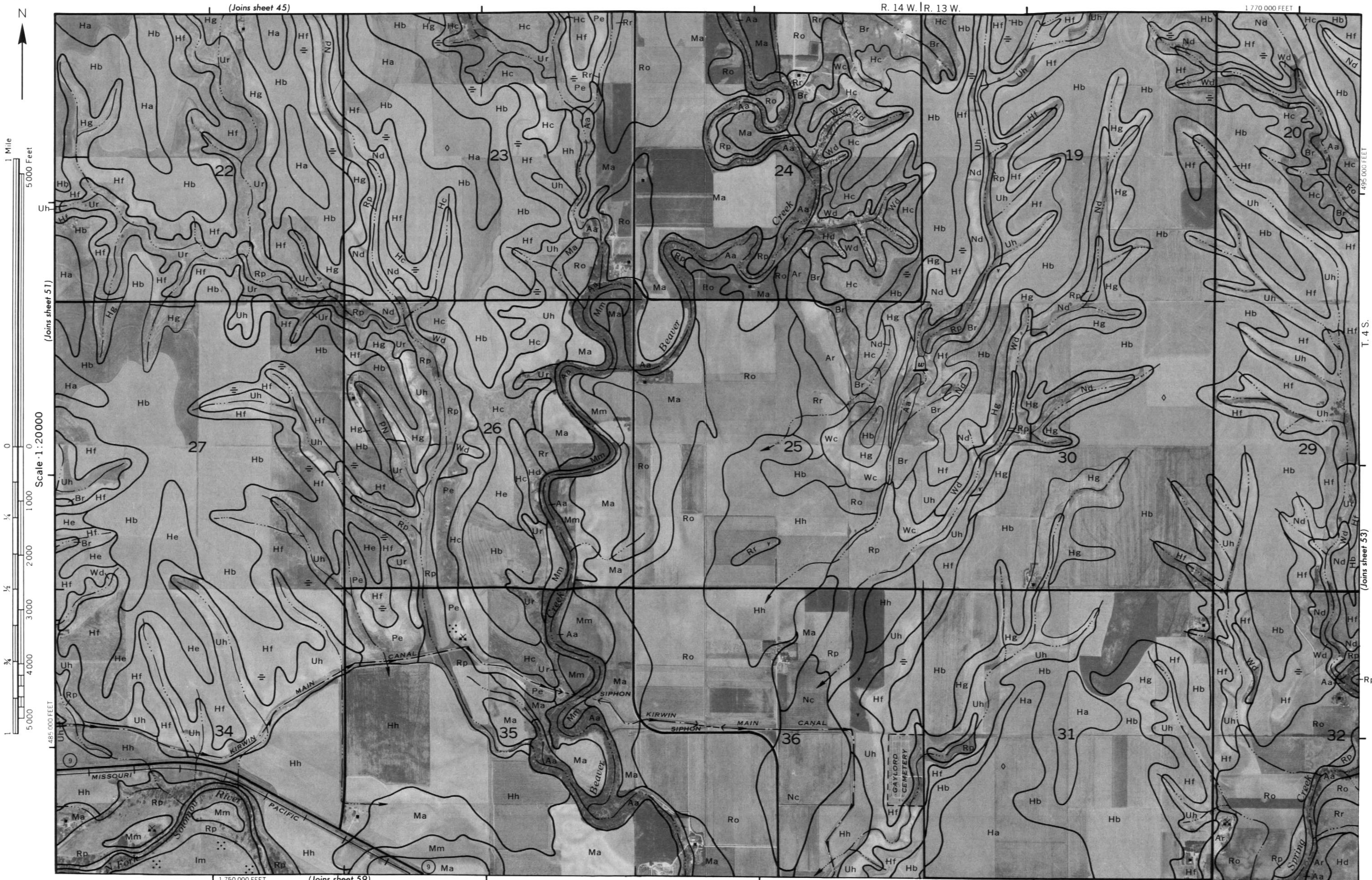
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 50

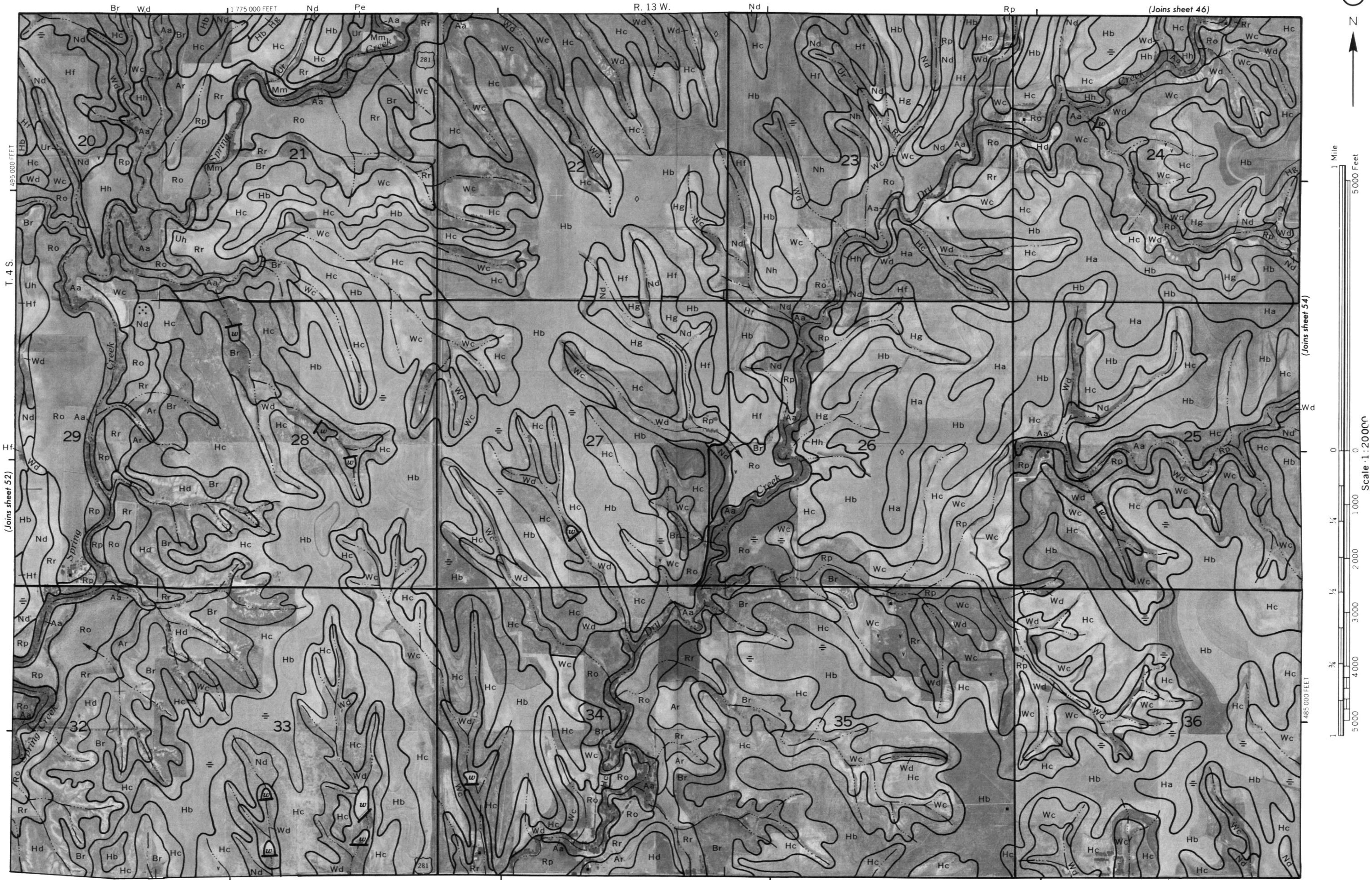
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

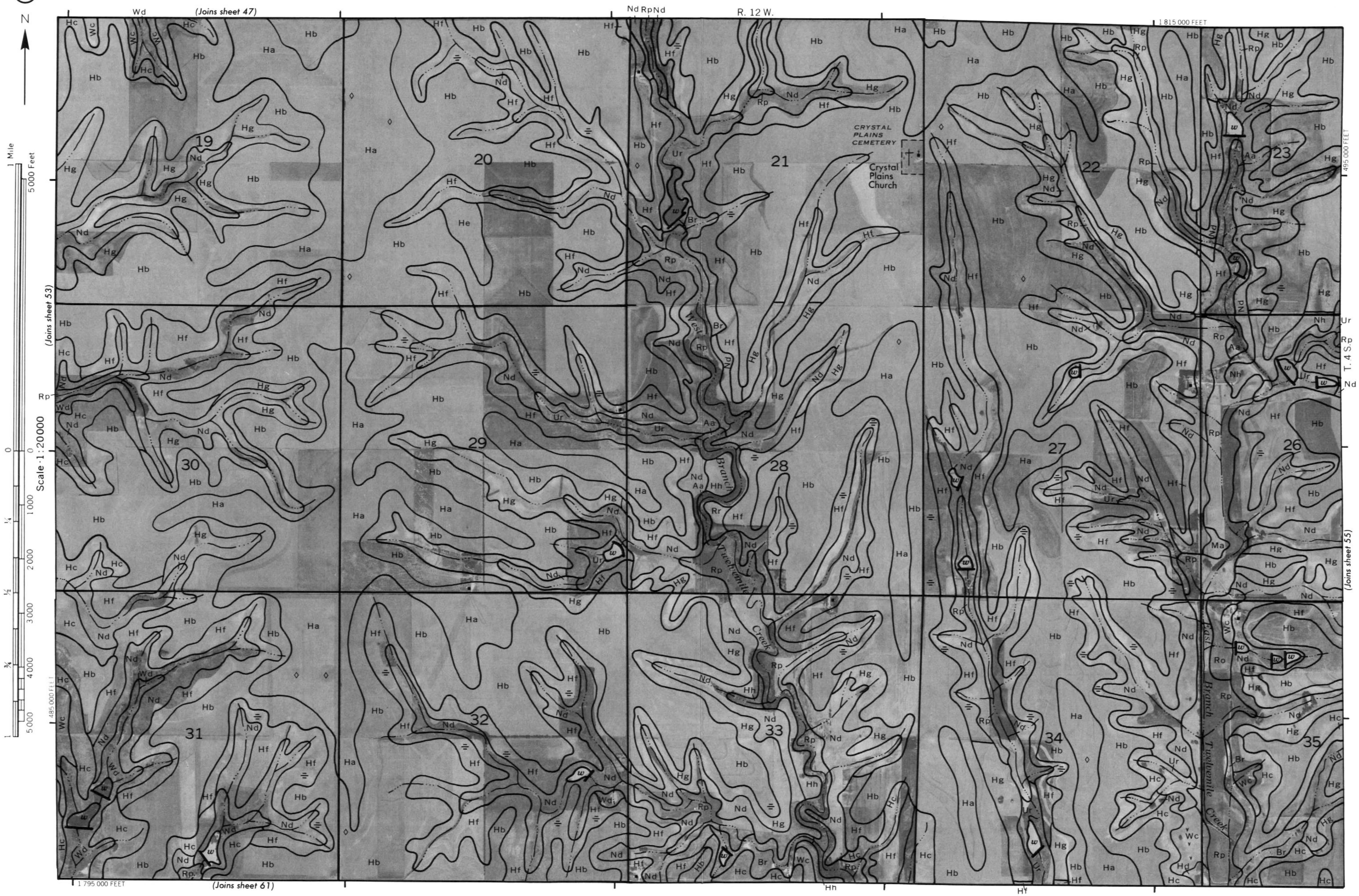


This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

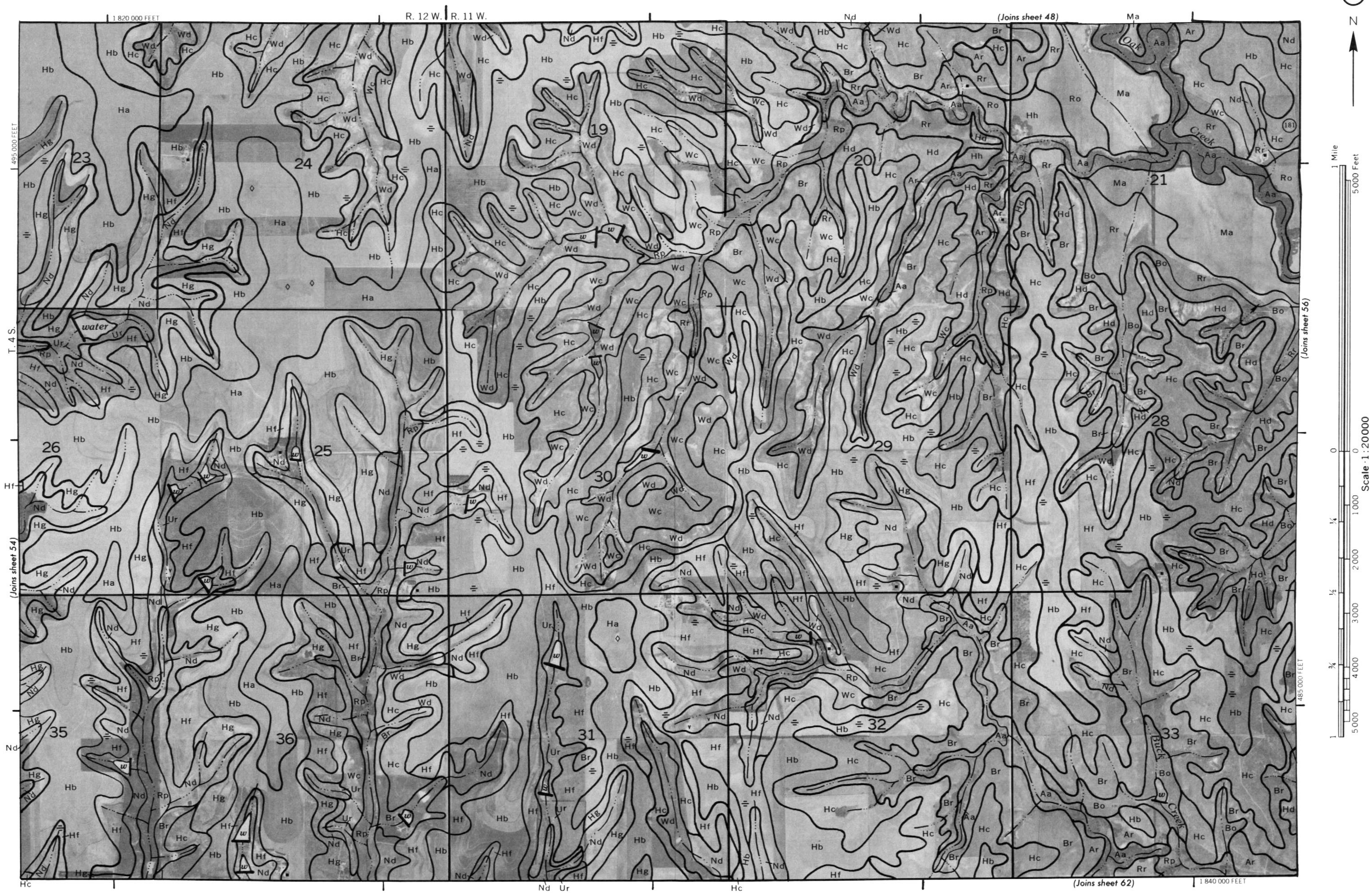


This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

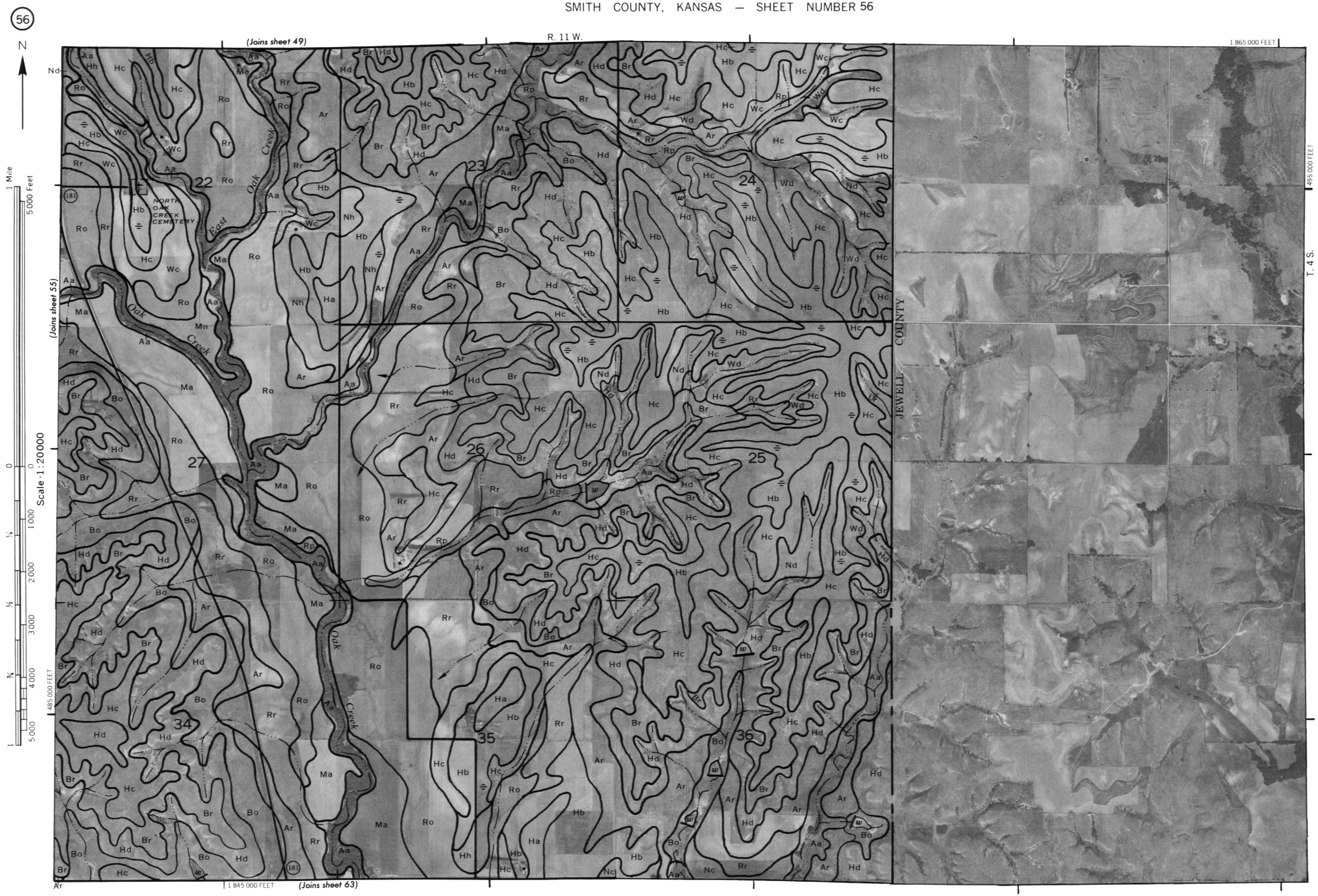
SMITH COUNTY, KANSAS — SHEET NUMBER 54



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

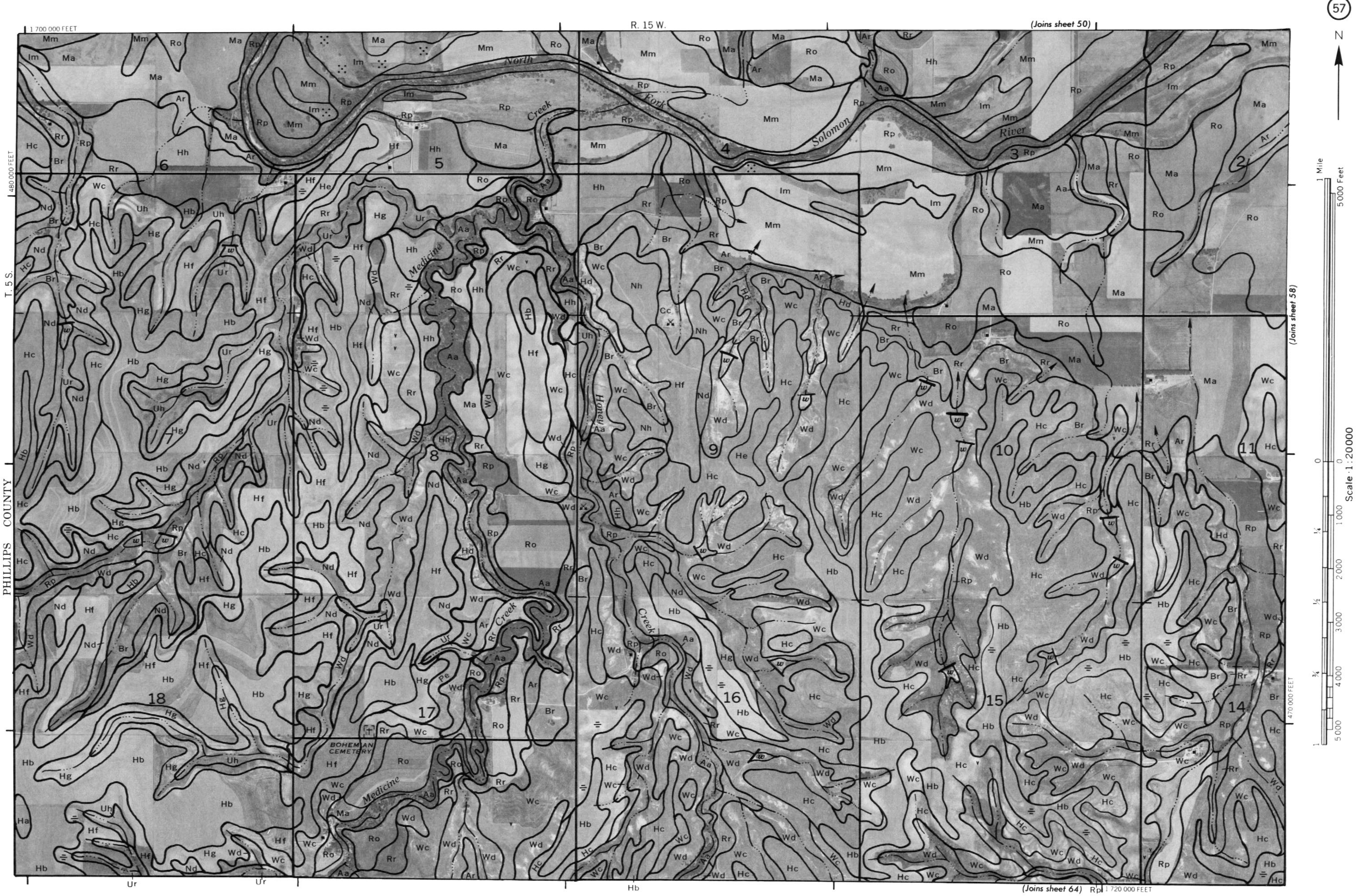


This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 57



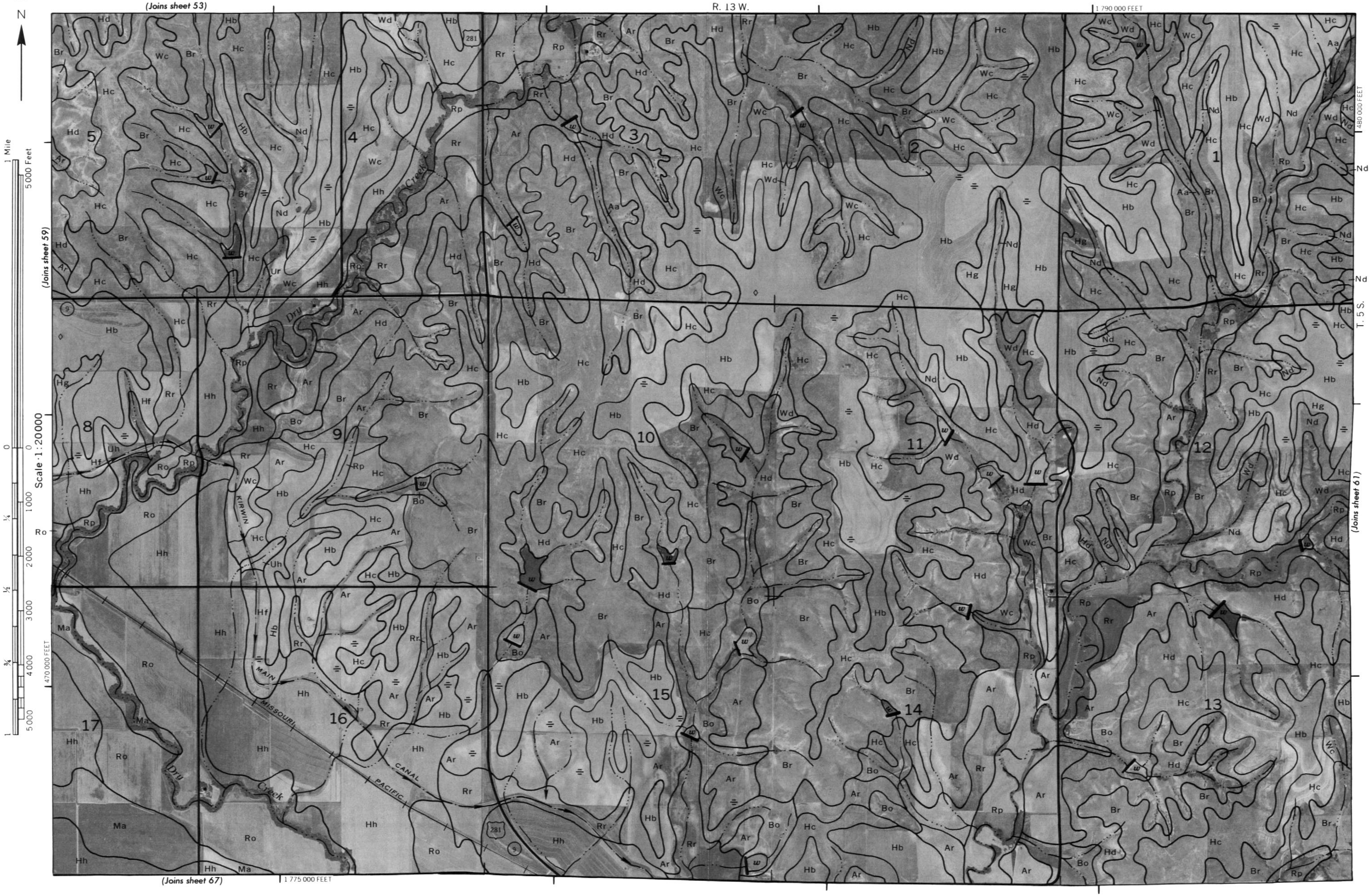
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 58

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.


N
1 750 000 FEET
R. 14 W.
R. 13 W.
(Joins sheet 52)
480 000 FEET
T. 5 S.
(Joins sheet 58)
(Joins sheet 60)
470 000 FEET
(Joins sheet 66)
1 770 000 FEET
Gaylord
MISSOURI PACIFIC
Beaver Creek
North Fork Solomon River
KIRWIN CANAL
KIRWIN MAIN CANAL
SIPHON
Spring Creek
1
2
3
5
6
7
8
10
11
12
13
14
15
17
18
Scale 1:20000
1 Mile
5000 Feet
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

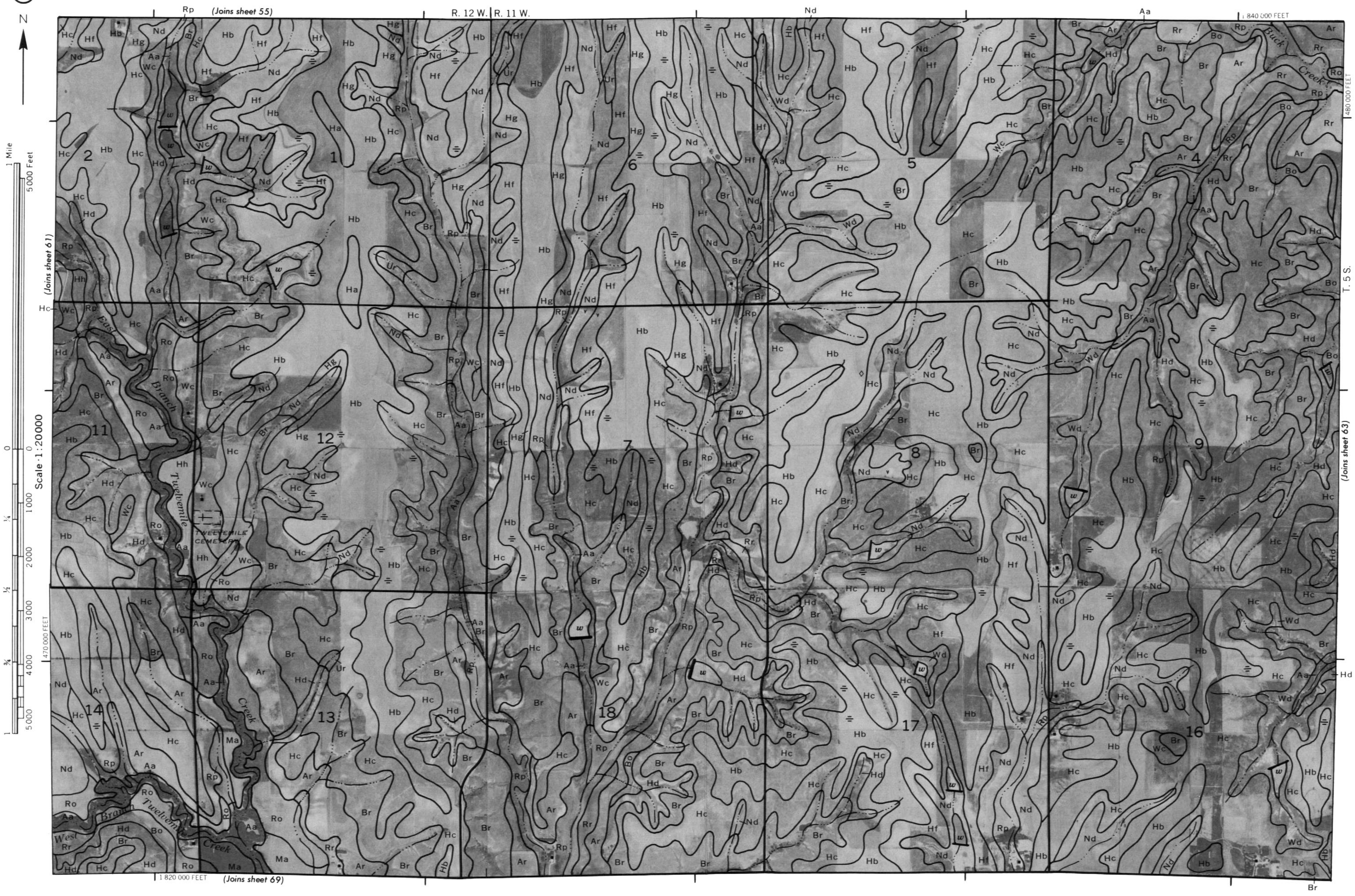
SMITH COUNTY, KANSAS — SHEET NUMBER 60



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 62

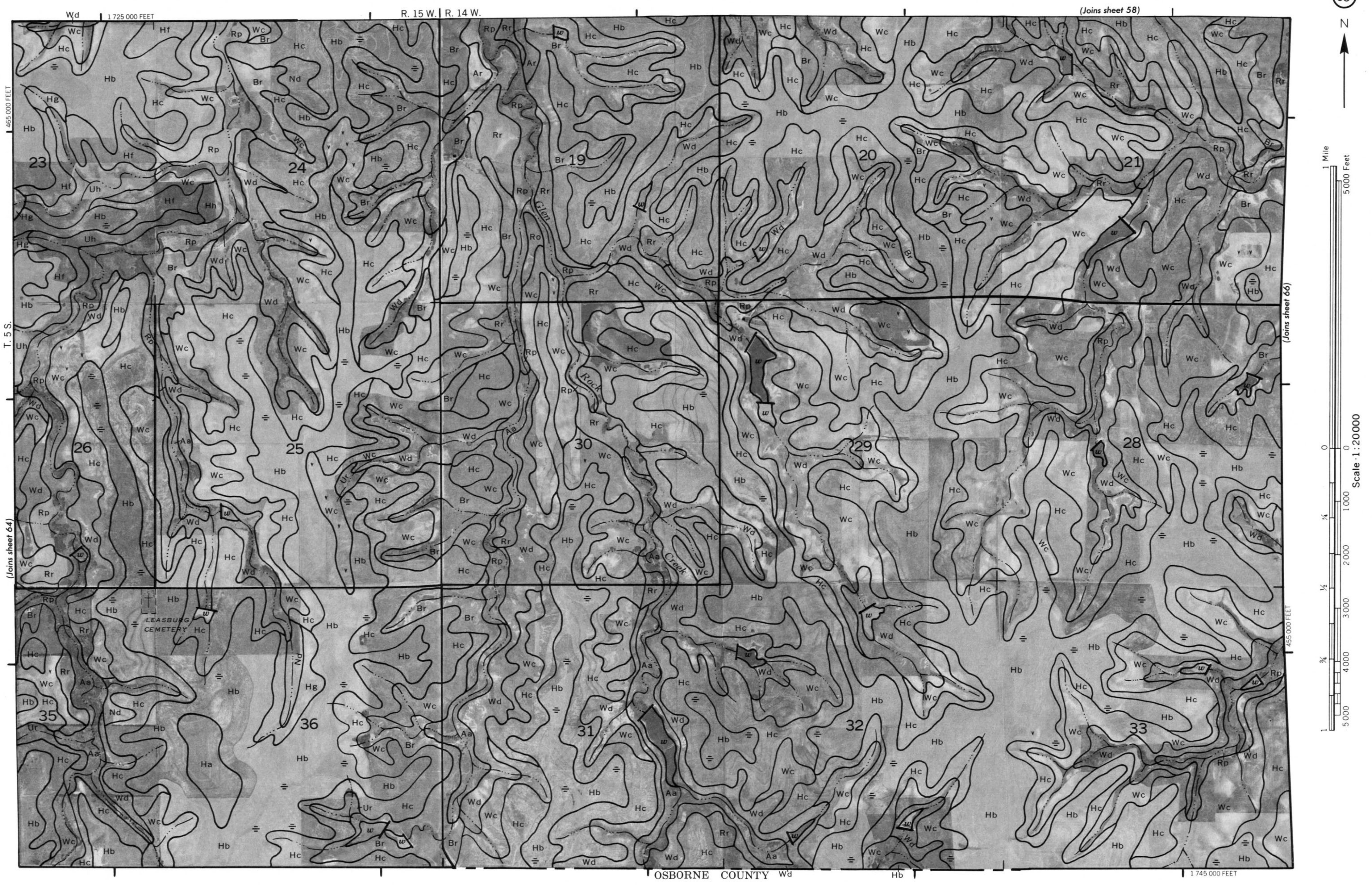


This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 64

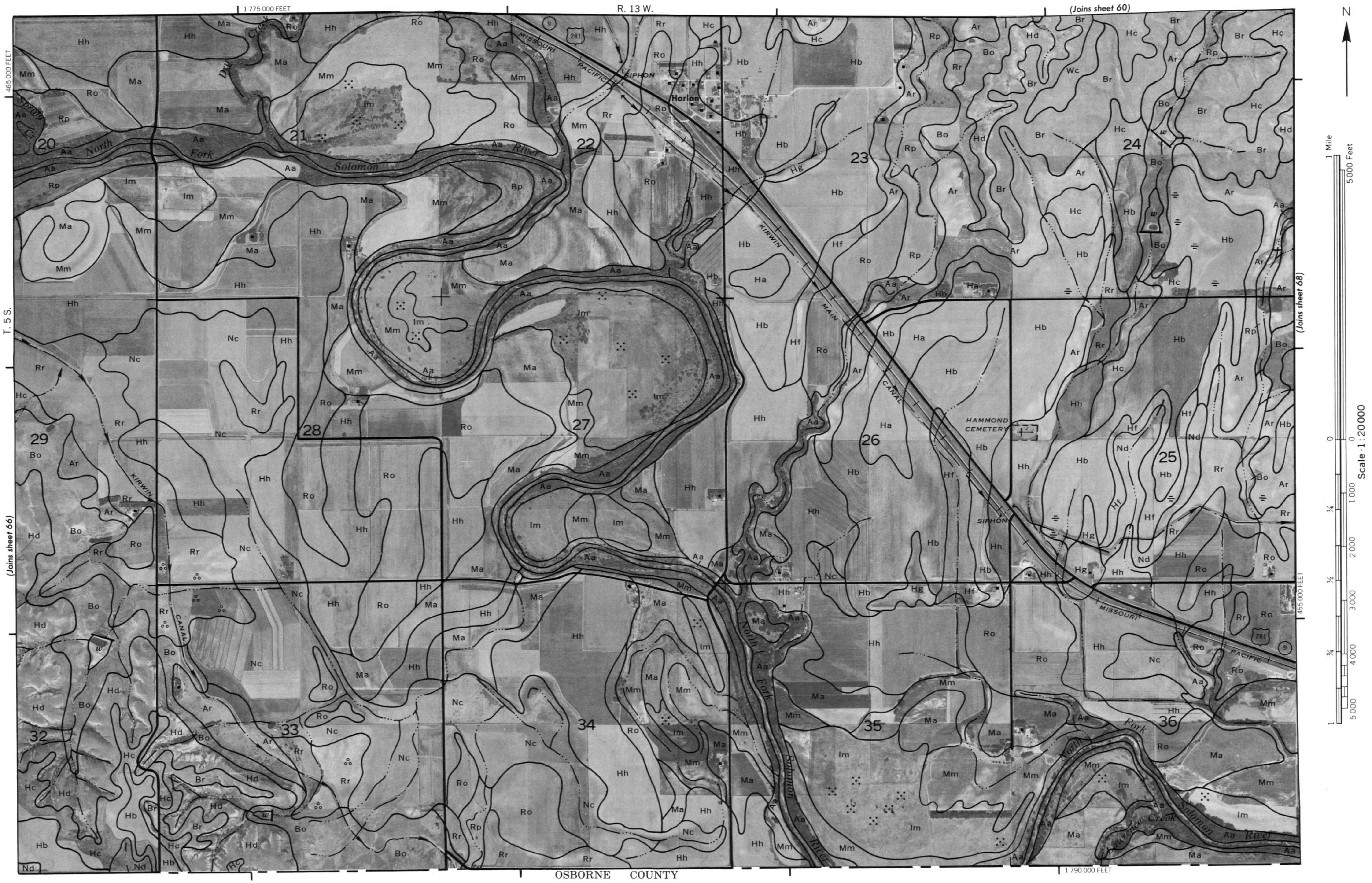
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SMITH COUNTY, KANSAS — SHEET NUMBER 66

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

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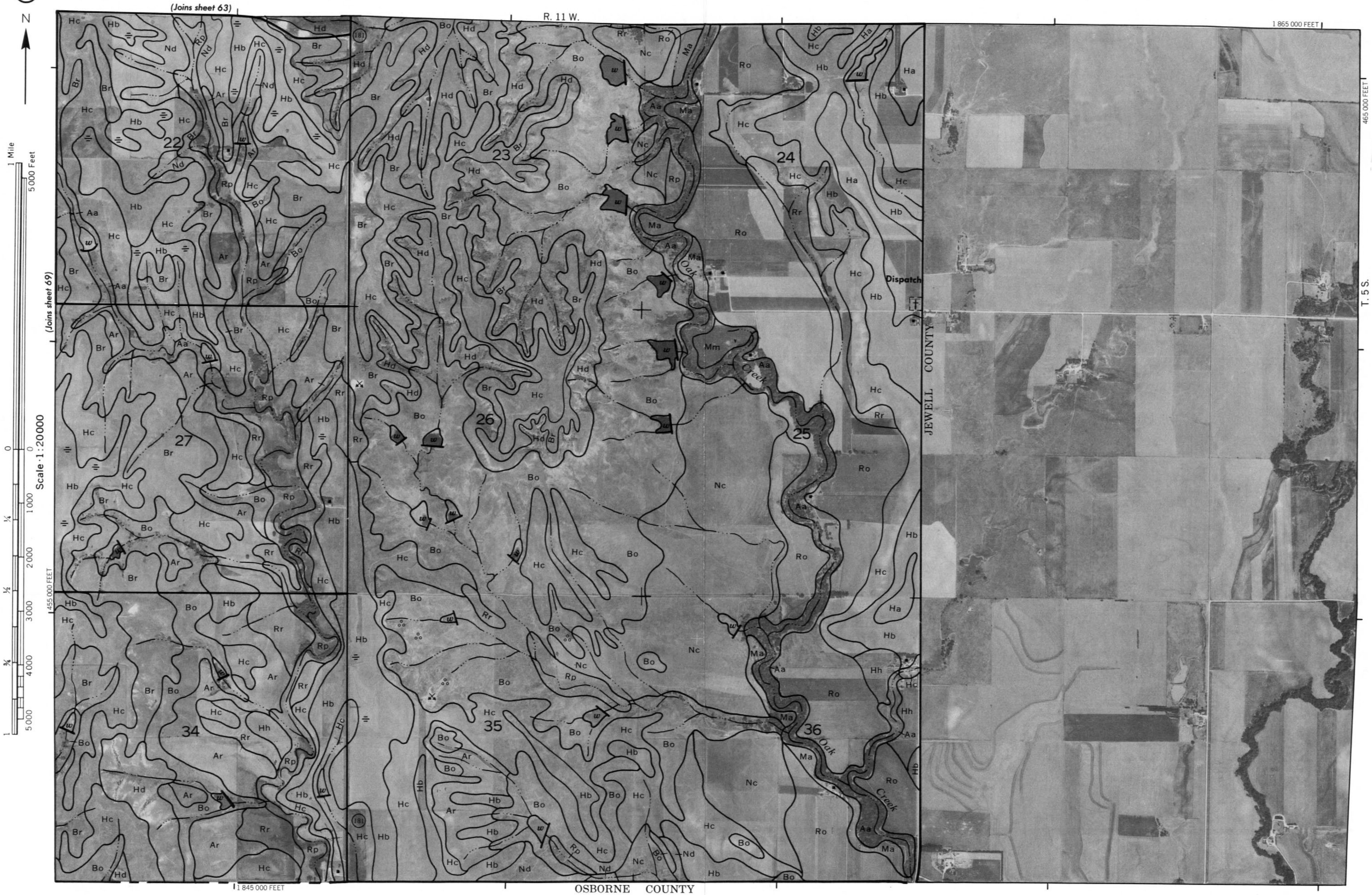
SMITH COUNTY, KANSAS — SHEET NUMBER 70



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.